Aviation Week and Space Technology

December 12, 1960

SPECIAL REPORTS:

BS 75 Turbofan

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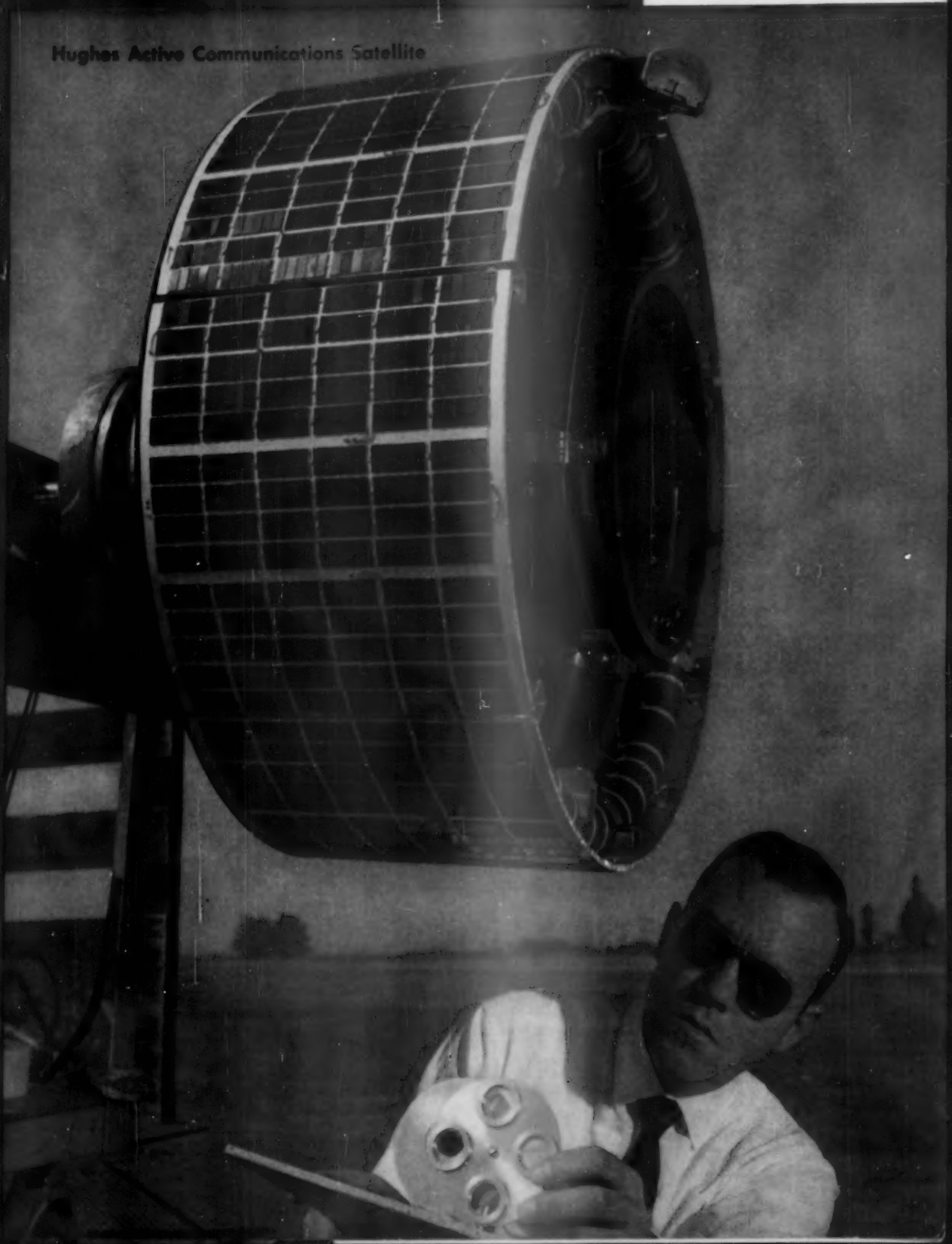
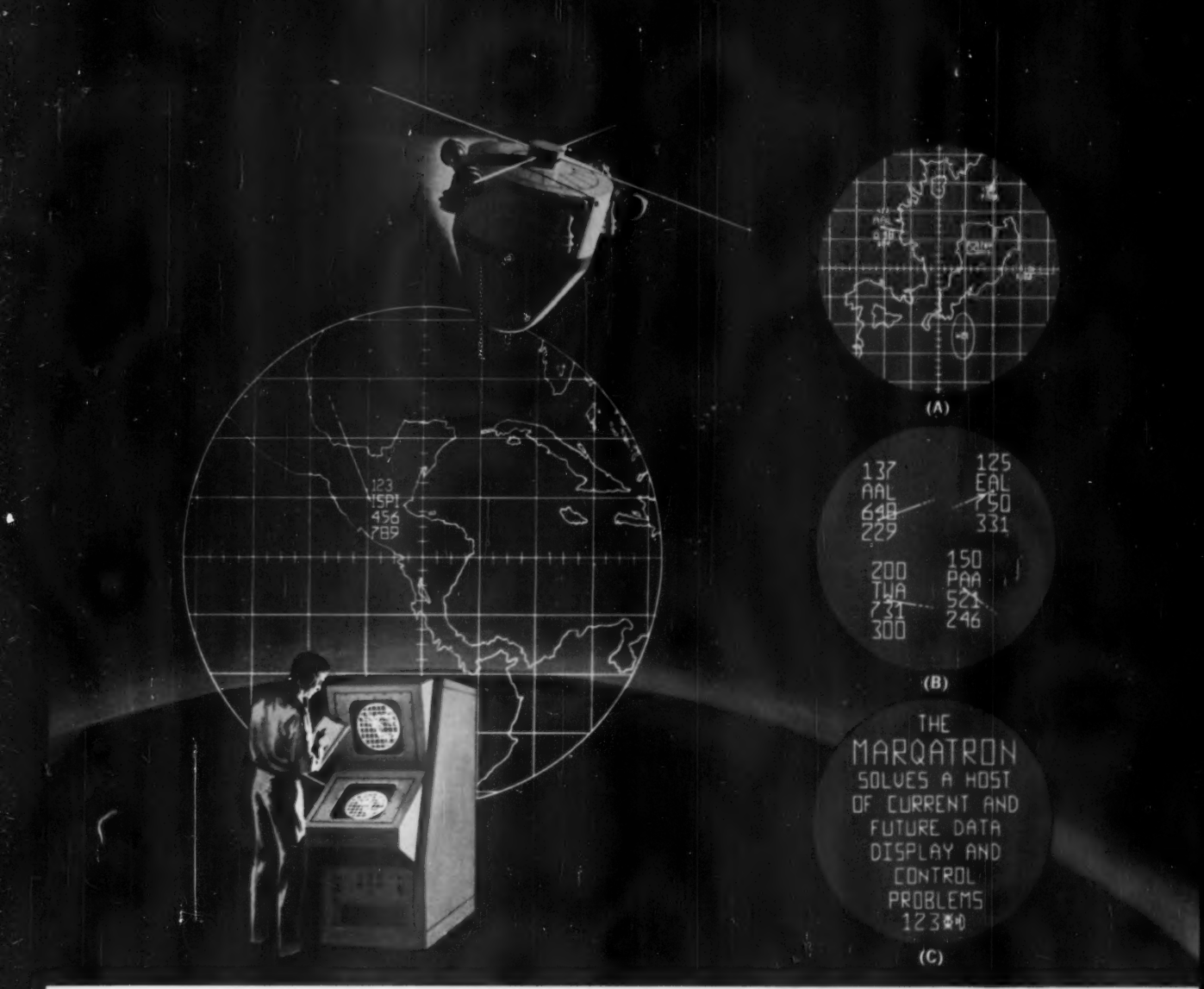
Continental 217



Hughes Active Communications Satellite



New MARQATRON by Marquardt/Pomona produces instant visual read-out from high-speed processed data

At the push of a button, any operator—skilled or unskilled—can read the answers of the fastest, most complex computers. The MARQATRON, an automatic data processing and display device from the Pomona Division of The Marquardt Corporation, instantly displays processed data in understandable alpha-numeric and/or geometric patterns. The MARQATRON—an advanced version of the Digitron—optimizes the efficiency of the man-machine relationship providing the viewer with pertinent information necessary to make immediate and intelligent control decisions, or to interpret any test or situation. Visual images are presented on a cathode ray screen.

MARQATRONS are presently in operation in the U.S. Army Missile Master Program providing defense officers with surveillance information necessary to the deployment of all missile ordnance.

A modified MARQATRON is being used on the Eagle Program by Bendix helping to determine the behavior of an experimental aerodynamic vehicle.

The uses of the MARQATRON are limitless in the fields of data processing, display, and large scale projection systems.

For detailed information on applications and new developments contact Dr. Wendell B. Sell, Vice President, Pomona Division, The Marquardt Corporation, 2709 North Garey Avenue, Pomona, California.

(A) COMMAND CONTROL—Visual displays for satellite tracking, defense intercept and missile training.

(B) AIR TRAFFIC CONTROL—Accurate positional data for enroute approach, ground control, and for identification of air traffic.

(C) PAGE PRINTING FORMATS—Temporary readout of multichannel data for visual program verification.

Scientists and engineers experienced in these or related fields will find it rewarding to discuss their career futures with The Marquardt Corporation.

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THE Marquardt CORPORATION

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CAPABILITY
is spelled
a-u-x-i-l-i-a-r-y
p-o-w-e-r

In technology and facility, Vickers continually matches your need

Experience gained on every type of military aircraft and commercial airliner plus numerous missile applications assures top performance from every Vickers auxiliary power package. Either complete and separate power generating systems or motorpumps can be provided depending on specific application requirements.

Precise performance evaluation—particularly on motorpumps—can often be provided even before the final package is developed from proved standard elements by building up prototype units and subjecting them to feasibility and performance tests. From these prototypes come the ultimate custom designed packages providing a high order of reliability and requiring minimum input power—all in a compact, lightweight envelope.

Additional data is available in two new Vickers bulletins: A-5239 "Power Systems" and A-5258 "Motorpumps". Write for your copies to either address listed below.

All components of Vickers auxiliary power units are subjected to thorough inspection by skilled technicians following evaluation tests. New size of standard element is shown being inspected following 40,000 rpm cycle test.

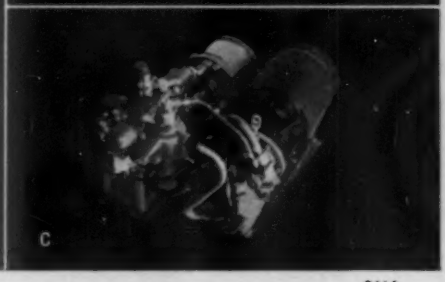
A. Battery-powered motorpumps developed for each stage of an ICBM missile.

B. Integrated motorpump for one of newest IRBM missiles.

C. Integrated AC motor-hydraulic power supply for intercontinental bomber turret drive.

Final testing, evaluation and assembly is performed in a special, surgically clean room. Thus, once parts are super-cleaned, no additional contamination is introduced.

TYPICAL AUXILIARY POWER PACKAGES DEVELOPED BY VICKERS:



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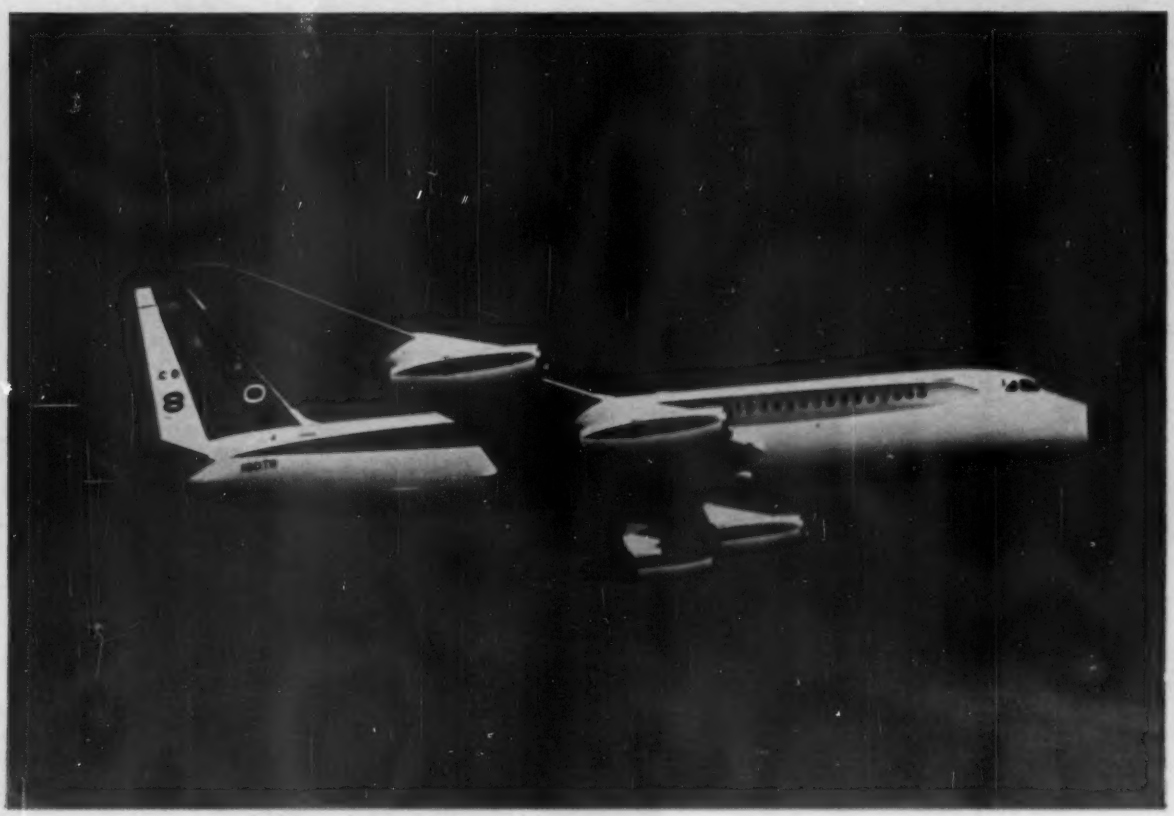
SILICONE NEWS from Dow Corning

Over-the-Weather Seals



Silastic: Seals at Extreme Temperatures and Altitudes

The new Convair 880 is designed to fly *over* most bad weather along intercontinental jetliner routes. So that its passengers can ride in air conditioned comfort, the cabin window seals must be designed with materials that resist the —60 F temperatures and ozone content of high altitudes. That's why engineers at Convair, San Diego, Division of General Dynamics Corporation chose Silastic®, the Dow Corning silicone rubber, as the seal for the more than 80 windows of the 880 Jet-Liner.

Silastic is flexible and rubbery at —130 F and does not harden and crack when exposed to ozone. This permits efficient and long lasting seals that stay in place . . . keep cabin air leakage and heat loss to a minimum . . . maintenance to detect and repair leaks is not required.

And there are other exposed seals, too, designed with Silastic. For example, the Convair 880's nose wheel door closes on a seal made of Silastic. Most rubber fabricators supply gaskets, seals, O-rings and other rubber parts made from Silastic. Why not investigate?

Courtesy Convair Division, General Dynamics Corp.

New brochure—"Silicones Solve Space Age Problems" Write Dept. 1012.

first in silicones

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MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

AVIATION CALENDAR

Dec. 26-31—127th Meeting, American Association for the Advancement of Science, New York, N. Y.

Dec. 28-30—Seventh King Orange International Model Plane Meet, Miami, Fla.

Jan. 9-11—Seventh National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia, Pa.

Jan. 9-13—International Congress and Exposition, Society of Automotive Engineers, Cobo Hall, Detroit, Mich.

Jan. 15-18—13th Annual Convention, Helicopter Assn. of America, Cherry Hill Inn, Haddonfield, N. J.

Jan. 16-18—Seventh Annual National Meeting, American Astronautical Society, Dallas, Tex.

Jan. 17-19—Winter Instrument-Automation Conference & Exhibit, Instrument Society of America, Jefferson Hotel and Kiel Auditorium, St. Louis, Mo.

Jan. 23-25—29th Annual Meeting, Institute of the Aeronautical Sciences, Hotel Astor, New York, N. Y. Honors Night Dinner, Jan. 24.

Feb. 1-3—Second Winter Military Electronics Convention, Institute of Radio Engineers, Biltmore Hotel, Los Angeles.

Feb. 1-3—Solid Propellants Conference, American Rocket Society, Salt Lake City.

Feb. 14-16—Second Annual Symposium on Non-destructive Testing of Aircraft and Missile Components (unclassified), Society for Non-destructive Testing and Southwest Research Institute, Gunter Hotel, San Antonio, Tex.

Feb. 15-17—International Solid-State Circuits Conference, Institute of Radio Engineers, Sheraton Hotel, Philadelphia.

(Continued on page 6)

AVIATION WEEK and Space Technology

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Photo courtesy Radio Corporation of America

aerospace

Components for RVX and TIROS Projects by LAVELLE

Major successes in the nation's accelerated space vehicle and missile programs include precision sheet metal components made by Lavelle. Among these is the fabrication by Lavelle of the structure of the new U. S. earth-circling TIROS weather observation satellite produced for the National Aeronautics and Space Administration by the Astro-Electronics Products Division, RCA. An artist's view of TIROS in orbit is shown above.

Photo courtesy World Wide Photos, Inc.

Pictured also is the recovery of the first successful RVX series re-entry vehicle after ICBM range flight. The aluminum alloy nose cone structure for this test was fabricated by Lavelle under sub-contract from the General Electric Company's Missile and Space Vehicle Department.

Some of the reasons why Lavelle has been selected to be a part of such dramatic projects are illustrated in a new brochure. Write for your copy.

Lavelle

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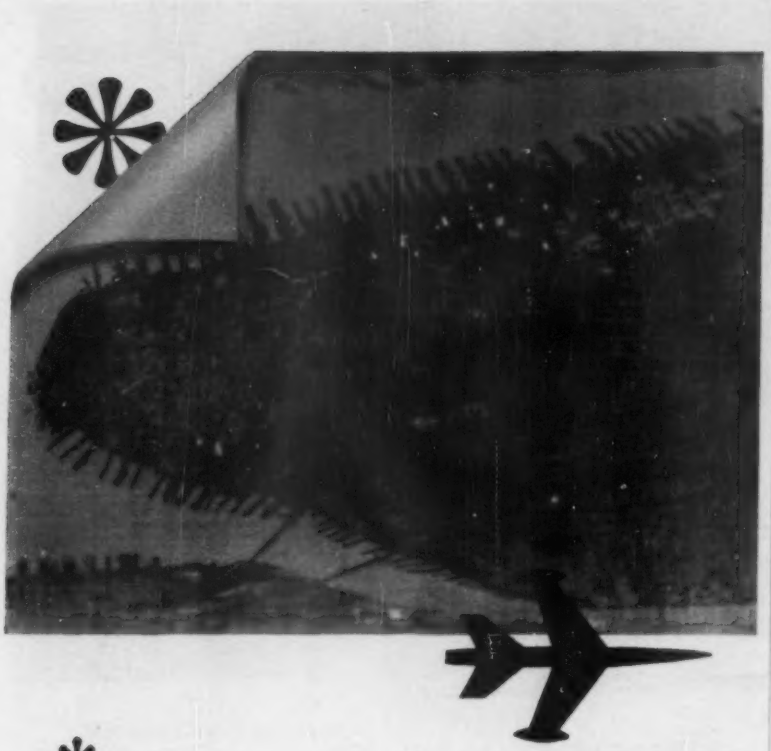

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a major advance in the state of infrared art

by HRB-SINGER, INC.

At long last HRB is permitted to admit openly their relationship to the revolutionary "Manhattan Strip," taken with IR equipment developed at HRB-SINGER. The map-like image was photographed under conditions of complete darkness. Amazingly clear, accurate and continuous data of the Manhattan terrain resulted.

IR surveillance equipment which meets military requirements, is continually being developed and improved at HRB-SINGER. Although RECONOFAX, the trade name applied to HRB IR equipment has been employed primarily in aircraft, it could be used in other vehicles such as satellites for scanning areas several hundred miles wide.

If you are interested in HRB's outstanding advances in the development of new concepts and systems for reconnaissance, surveillance, and infrared detection—military and industrial personnel with a need to know, contact HRB-SINGER, Dept. I.

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Science Park, State College, Pa.

SINGER

AVIATION CALENDAR

(Continued from page 5)

Mar. 5-9—Sixth Annual Gas Turbine Conference and Exhibit, American Society of Mechanical Engineers, Shoreham Hotel, Washington, D. C.

Mar. 9-10—Second Symposium on Engineering Aspects of Magnetohydrodynamics, University of Pennsylvania, Philadelphia.

Mar. 9-10—Flight Propulsion Meeting, Institute of the Aeronautical Sciences, Cleveland, Ohio (classified).

Mar. 12-16—Aviation Conference, American Society of Mechanical Engineers, Statler-Hilton, Los Angeles, Calif.

Mar. 13-15—Flight Testing Conference, American Rocket Society, Los Angeles.

Mar. 13-16—Test, Operations and Support Conference, American Rocket Society, Biltmore Hotel, Los Angeles, Calif.

Mar. 16-18—Fifth National Conference on Aviation Education, Mayflower Hotel, Washington, D. C.

Mar. 20-23—International Convention, Institute of Radio Engineers, Coliseum and Waldorf Astoria Hotel, New York, N. Y.

Mar. 20-24—1961 Western Metal Exposition, American Society for Metals, Pan-Pacific Auditorium, Los Angeles, Calif.

Mar. 27-31—1961 Symposium on Temperature, Its Measurement and Control in Science and Industry, Columbus, Ohio. For information: V. W. Sikora, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

Apr. 4-6—International Symposium on Electromagnetics and Fluid Dynamics of Gaseous Plasma, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Apr. 5-7—Lifting Re-entry Vehicles: Structures, Materials & Design, American Rocket Society, Palm Springs, Calif.

Apr. 10-11—Spring Meeting, Western States Section/The Combustion Institute, Aeronutronics Division of Ford Motor Co., Newport Beach, Calif.

Apr. 17-28—14th Technical Conference, International Air Transport Assn., Queen Elizabeth Hotel, Montreal, Canada.

Apr. 18-20—Symposium on Chemical Reactions in the Lower and Upper Atmosphere, Stanford Research Institute, Mark Hopkins Hotel, San Francisco, Calif.

Apr. 20-22—General Meeting, American Meteorological Society with the American Geophysical Union, Washington, D. C.

Apr. 26-28—Liquid Rockets, Propellants and Combustion Conference, American Rocket Society, Palm Beach Biltmore, Palm Beach, Fla.

Apr. 30-May 4—Seventh National Aero-Space Instrumentation Symposium, Instrument Society of America, Adolphus Hotel, Houston, Tex.

May 8-10—National Aeronautical Electronics Conference, Institute of Radio Engineers, Miami and Biltmore Hotels, Dayton, Ohio.

May 9-11—Western Joint Computer Conference and Exhibit, Ambassador Hotel, Los Angeles, Calif.

May 22-24—National Telemetering Conference, Sheraton-Towers Hotel, Chicago, Ill.

May 26-June 4—24th French International Air Show, Le Bourget, Paris, France.

Sept. 4-10—1961 Flying Display and Exhibition, Society of British Aircraft Constructors, Farnborough, England.

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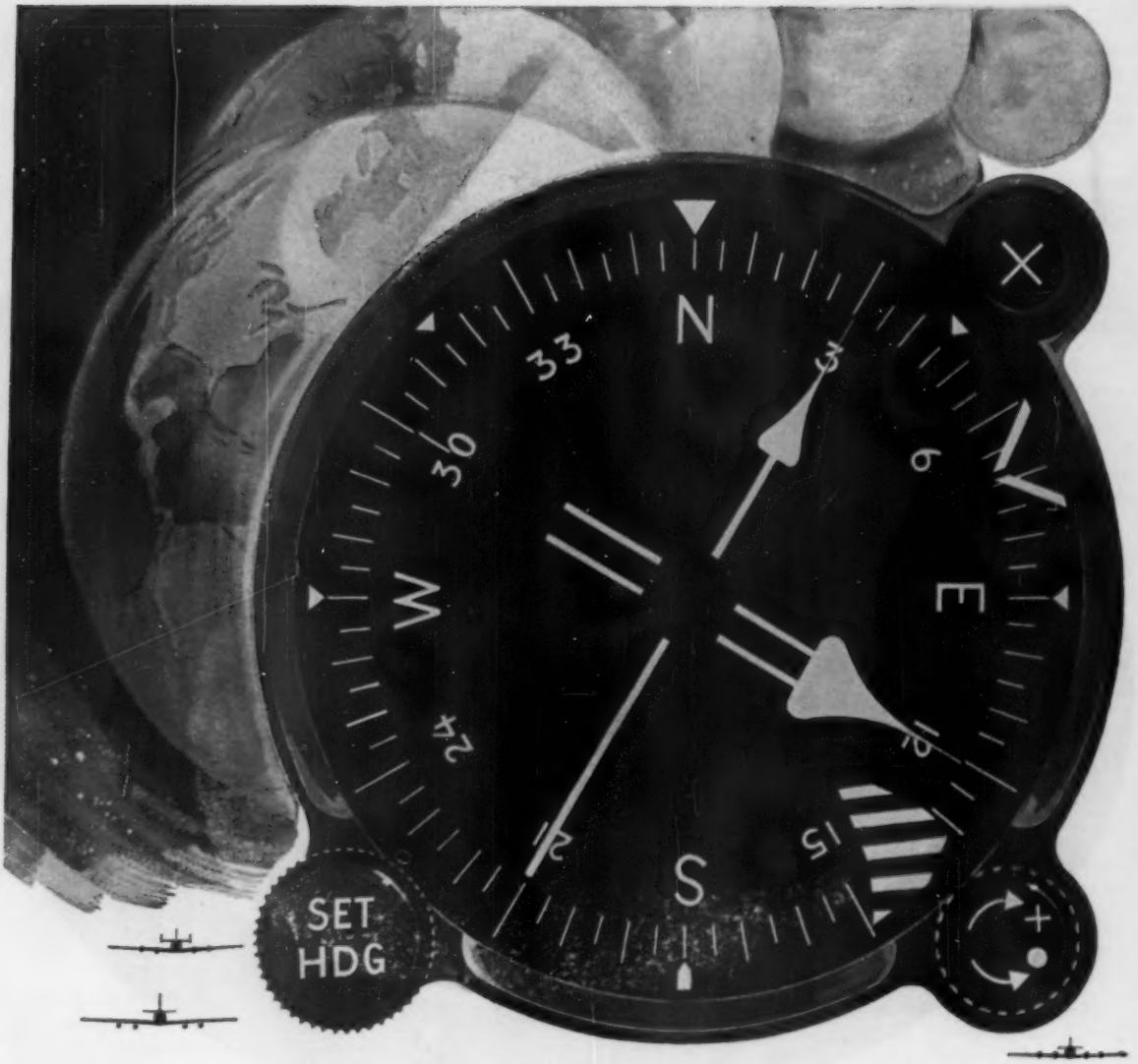

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GYROSYN COMPASSES

...the heart of precision navigation

The directional gyro continuously synchronized to the earth's magnetic field . . . the Sperry Gyrosyn® Compass that revolutionized heading information for flying when it was introduced in 1944 . . . is still at the heart of precision aircraft navigation. Today there is a Gyrosyn Compass System for all types of aircraft – military, commercial, executive and private.

The Gyrosyn combines the functions of both a directional gyro and a magnetic compass. The differences in the particular models—which include the C-2, C-4, C-8, C-9, C-10 and C-11—relate to size, weight, performance and cost consistent with the application.

The C-2 is the lightest and most compact system available, weighing only 8¼ pounds. The transistorized C-11 incorporates Rotorace® suspension to hold random drift within ± 0.5 degrees an hour in "free-gyro" operation on transpolar routes. As Doppler navigators come into widespread use, Gyrosyn systems will be a "must" in meeting critical accuracy requirements.

Sperry has produced and sold more high-accuracy compass systems than all other manufacturers combined.

SPERRY

SPERRY PHOENIX COMPANY, *DIVISION OF SPERRY RAND CORPORATION, PHOENIX, ARIZONA*

Photo and unretouched x-ray show automatic pilot grip for B-58 Hustler bomber. Plastics fabrication by Swedlow Control stick assembly by H. W. Loud Machine Works, Inc. B-58 by Convair, a Division of General Dynamics Corporation.

PILOT'S GRIP BY SWEDLOW: A STUDY OF ADVANCES IN REINFORCED PLASTICS

This pilot's hand grip must withstand 500 lbs. fore and aft pressure; 200 lbs. lateral pressure, yet be light in weight. It must contain a handful of electrical controls; over a score of connections—so it must have dependable electrical properties. Quite a problem. The Swedlow answer: an epoxy resin system and two forms of glass fabric...plus an ingenious multi-step molding and curing process to get the most from the materials. Result: a handle which meets specifications, needs only one-shot machining. The techniques and proprietary processes developed to solve this problem represent the most advanced skills and insight necessary for plastics fabrication today and tomorrow.

Put these Swedlow skills to work on your problem. Write for full information, to Dept. 10

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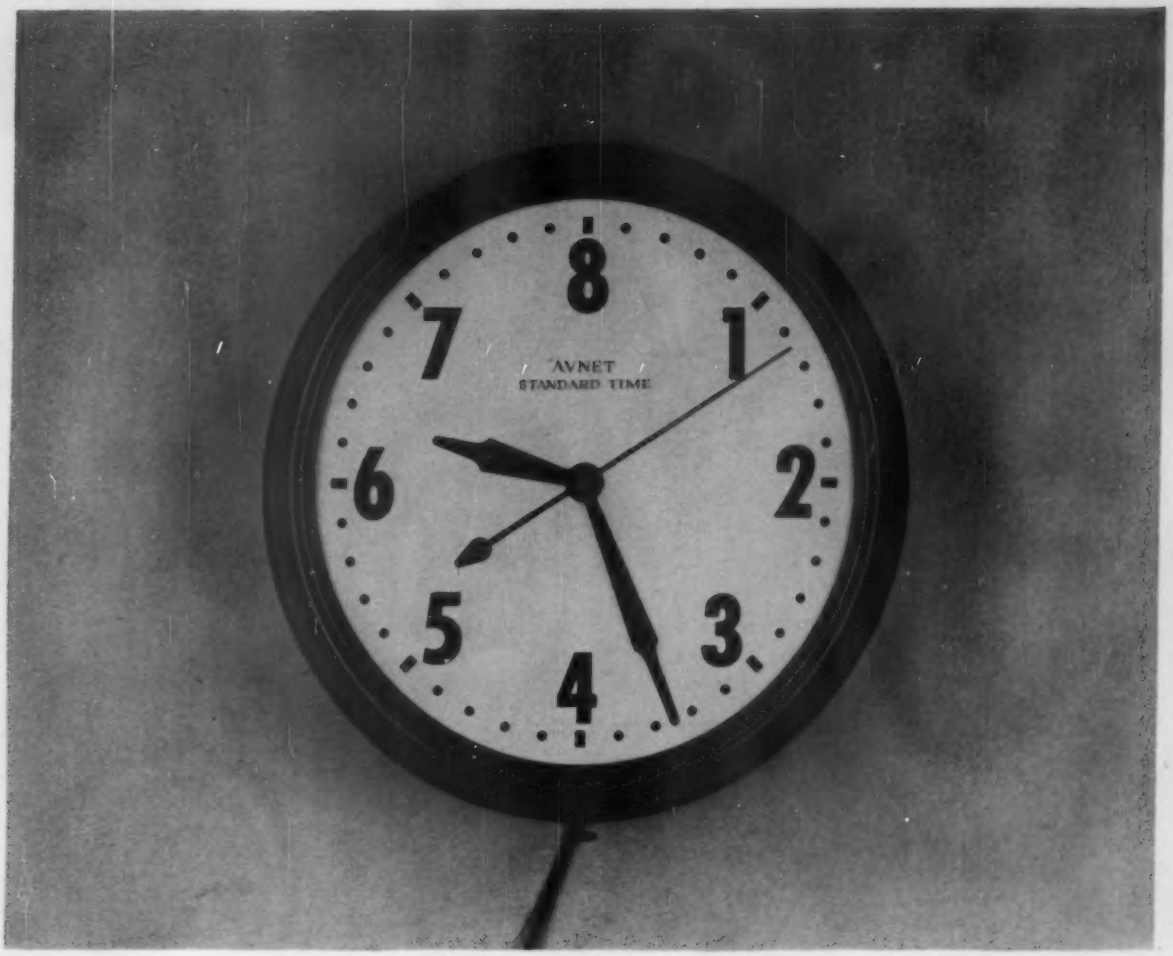

The Avnet System

creates a new Concept of Time

A normally expedient shipping time for your order would be 9:27, as shown by the hands on the clock above. *The Avnet System* would ship at 6:18. The few hour difference (or few day difference) might not be crucial, But if time *is* an important factor, use The Avnet System. Avnet Standard Time and Avnet Standard Procedures ship your order faster than any other major source for electronic components.

This new Concept of Time is one of the many advantages in The Avnet System. *Avnet maintains a network of Sales Engineers traveling the U.S. Each engineer has his counterpart in a Service Center Expediter. Tremendous stocking facilities are maintained strategically throughout the country. Avnet maintains and operates complete assembly facilities for Connector Prototype requirements.* Avnet's Concept of Time may gain you minutes, hours, days, money. Contact your nearest Service Center in The Avnet System.

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Avnet distributes from its stocking facilities: BENDIX SCINTILLA CONNECTORS, SPERRY SEMICONDUCTORS, RHEEM SEMICONDUCTORS, ELECTROSNAP AND HETHERINGTON SWITCHES, GREMAR CONNECTORS, CLARE RELAYS, ROBERTSON SPLICE & CONNECTOR CASES, BABCOCK RELAYS, KING SUBMINIATURE HI-TEMP CERAMIC CAPACITORS, TIC PRECISION TRIMMERS, VIBREX FASTENERS by GENERAL TIRE & RUBBER CO., U. S. SEMCOR SEMICONDUCTORS, SANGAMO CAPACITORS, SPRAGUE CAPACITORS

The new Beechcraft L-23F . . .

Meeting the U. S. Army's requirement for a modern high-performance, low-cost transportation system

Already serving the U. S. Army, the versatile new Beechcraft L-23F is the latest in a long line of high-performance training and utility aircraft which Beech Aircraft Corporation has designed, developed and produced for the military services since 1932.

With supercharged fuel injection engines, the L-23F combines high altitude cruise power with exceptional short field performance, rugged durability and low operating costs to meet a wide range of needs . . . as a command liaison or personnel transport, a carrier of high-priority cargo, an aerial ambulance, or a multi-engine instrument trainer with a "big plane" feel. Designed and engineered for future pressurization and turbo-prop modification.

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Beech Aerospace Division projects include R&D on manned aircraft; missile target and reconnaissance systems; complete missile systems; electronic guidance systems; programs pertaining to liquid hydrogen propellants and cryogenic tankage systems; environmental testing of missile systems and components; and GSE. May we help you? Write, wire, or phone Contract Administrator, Beech Aircraft Corp., Wichita 1, Kansas—or nearest Area Office.

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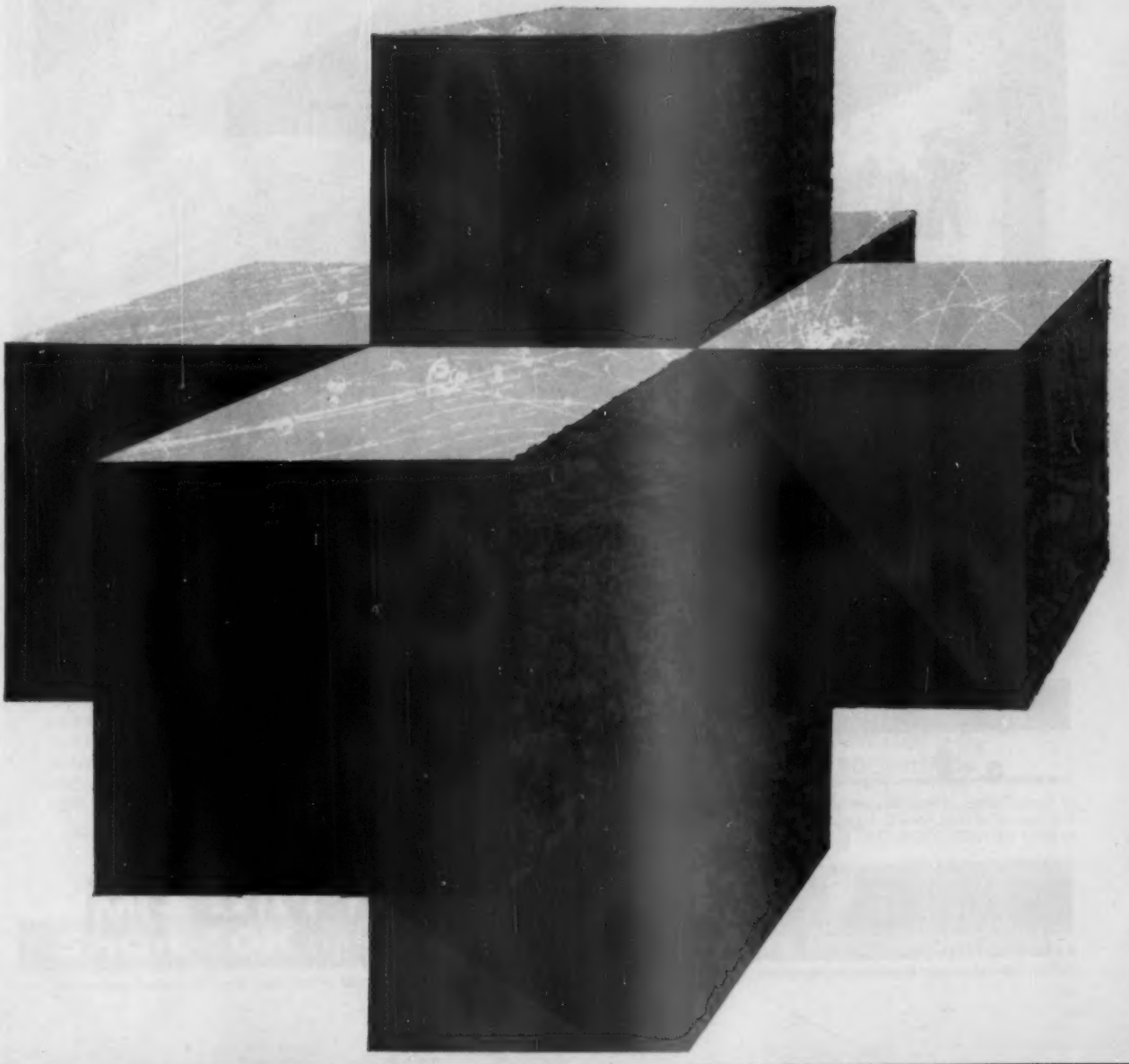
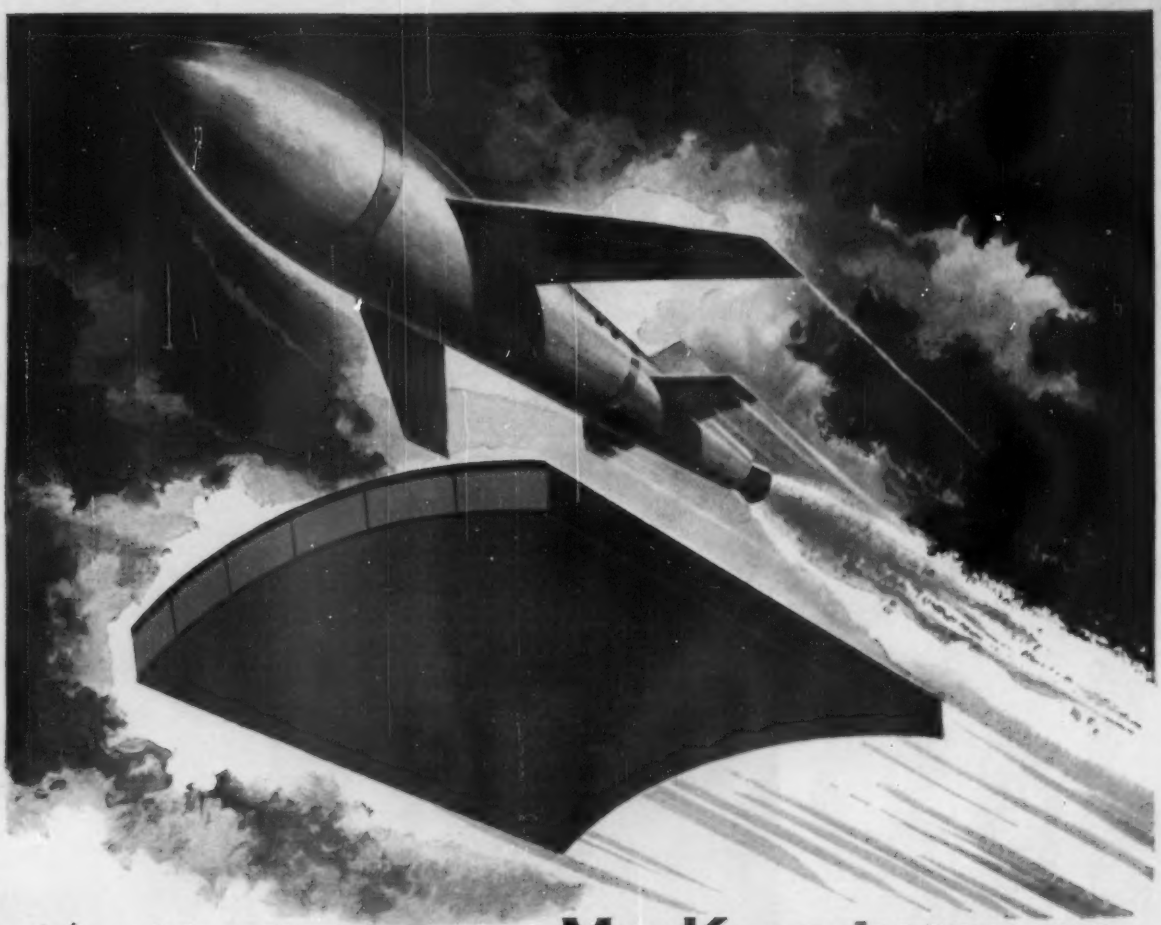




Johns-Manville Announces... MIN-KLAD INTERLOK

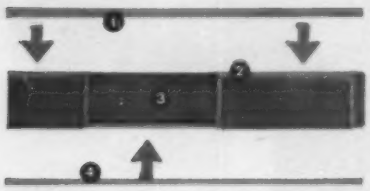
. . . a new structural system interlocking Min-K insulation and high-temperature reinforced plastic

Missile experience shows that in certain heat control situations no one material will perform as well as two (or more)—*an insulation with protective high-temperature facings.*

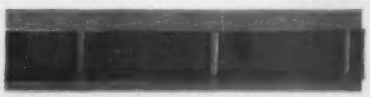
Problem is how to effectively combine these materials into a structurally strong unit? The answer is Min-Klad Interlok—a new structural system that interlocks Min-K insulation and reinforced plastic, metal or other high-temperature facings.

The result: one product that gives the missile designer every advantage of high-temperature plastic or metal foil—strength, toughness, rigidity! Erosion resistance! High heat capacity!

. . . plus the outstanding advantages of Min-K insulation—an insulating core that has the lowest thermal conductivity available for service temperatures up to 2000°F steady-state, and higher for transients. Min-K's thermal conductivity is actually lower than the molecular conductivity of still air.



1) Outer facing, 2) Interlocking web, 3) Core, any one of several Min-K formulations, and 4) Inner facing.



All the above components combine to provide a custom-made structural strong insulating system.

Wide range of facings

For the hot face, the missile designer can specify Min-Klad Interlok in a wide variety of heat-resistant and/or ablating materials—asbestos-phenolic (ARP-40), and similar reinforced plastics, as well as stainless steel and other heat-resistant metal foils and meshes. For some requirements, the cool face can be made of a different material—for example, one that offers characteristics required for bonding or fastening to other surfaces and parts.

Like all J-M Aviation insulations, Min-Klad Interlok is factory-fabricated to your specifications into external skin panels, heat shields, cylindrical liners or component housings of any shape or size. Write today for technical specifications. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

SAVING: $400,000!

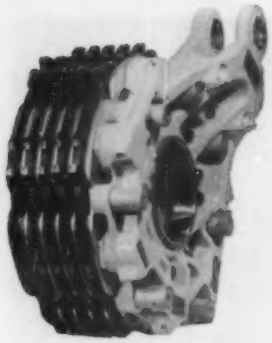
Sounds fantastic, doesn't it? Yet this is Convair's estimate for substituting SHUR-LOK CLIP NUTS for plate nuts in the production of 61 transport aircraft.

HOW IS THIS POSSIBLE? Since SHUR-LOK CLIP NUTS perform the same function as plate nuts but require neither rivets nor installation tools, up to **30¢-per-hole** saving can be realized. Two fingers and two seconds are all it takes.

REPLACEMENT? With no rivets to be drilled out, replacement is about a ten-second process. Saving here can be up to $1.00 each!

SHUR-LOK CORPORATION • 879 SOUTH EAST STREET, ANAHEIM, CALIFORNIA

In Canada: Railway & Power Engineering Corp., Ltd., Montreal, Quebec • In Great Britain: Teleflex Products Ltd., Basildon, Essex, England



THREE REASONS WHY BENDIX BRAKES ARE BETTER

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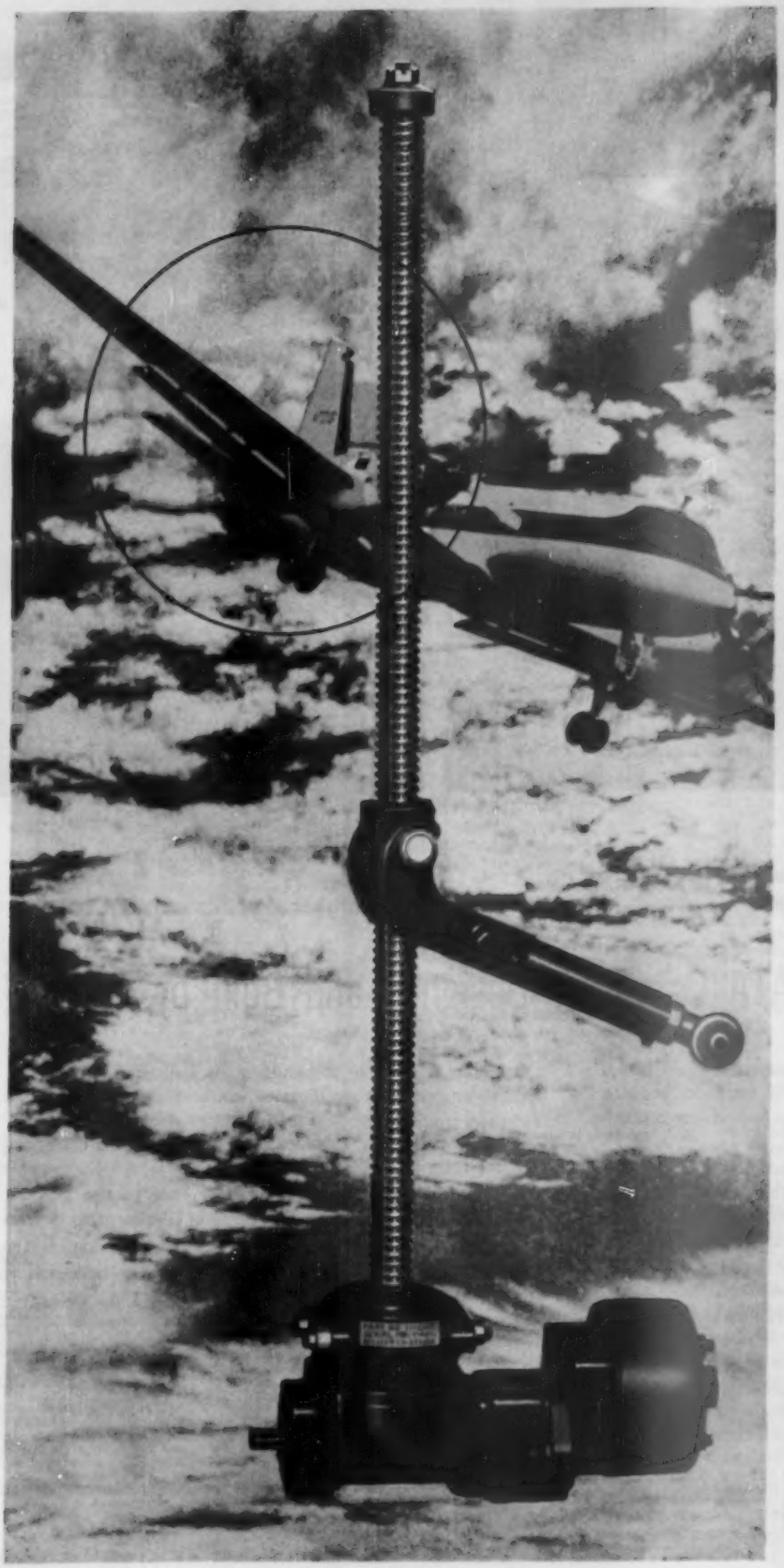

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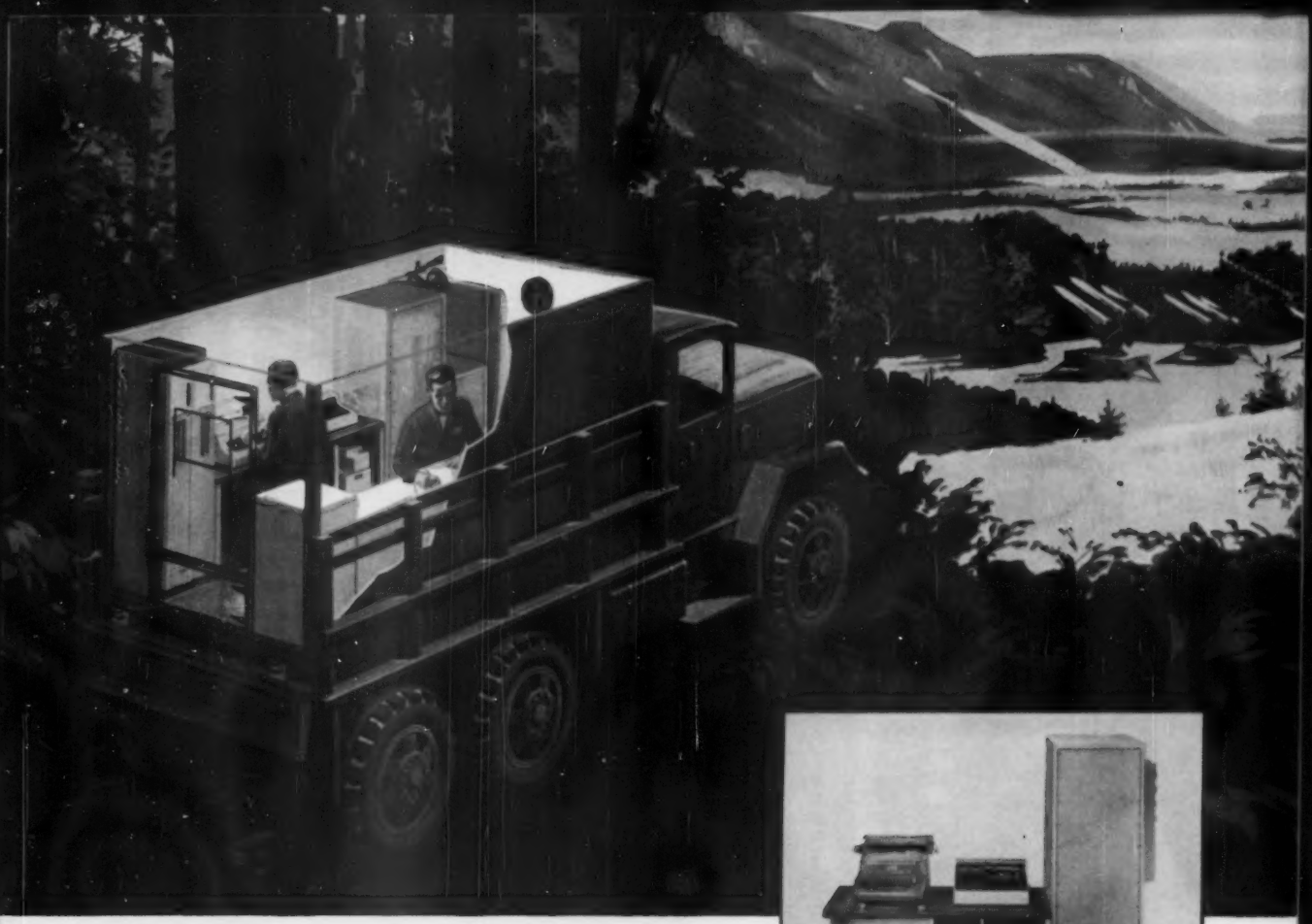

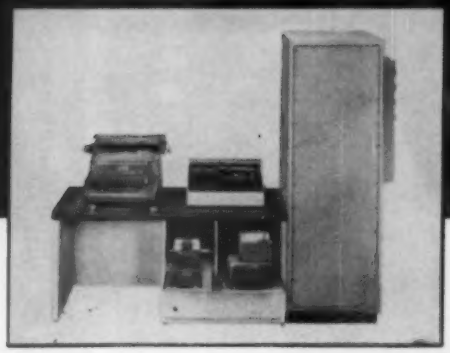

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Basicpac will be delivered in December to the U.S. Army Signal Research and Development Laboratory for final acceptance testing.

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COVER: Solar cell output from operating prototype of Hughes Aircraft Co. spin stabilized communication satellite is checked with pyroheliometer. Designed to be boosted into inclined synchronized orbit by Thor-Delta booster, payload weighs 52 lb. and can relay quantities of telephone teletype or a single TV channel across continents. Thirty-two pound commercial communication version of same payload, made of lighter material and equipped with less fuel for orbital corrections, can be launched into 22,752 naut. mi. high orbit from uninhabited equatorial island by relatively inexpensive modified NASA Scout four-stage solid propellant rocket (story on p. 52).

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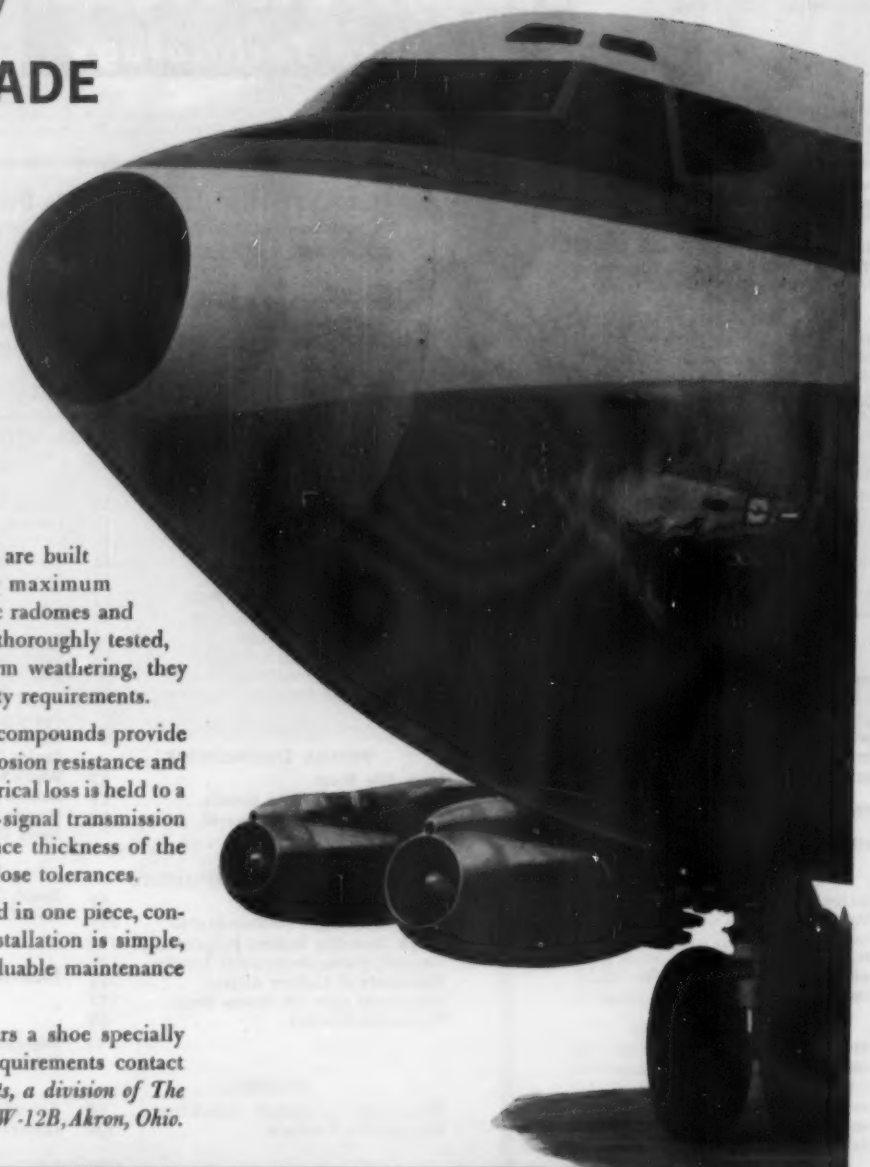

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EROSION SHOES ON BOEING 707 ANTENNA

UHF antenna

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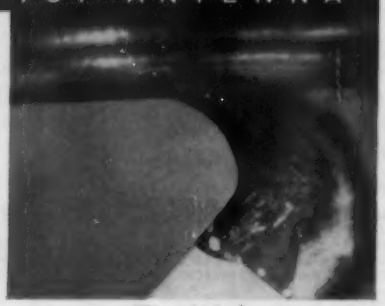


Wing tip probe

B.F.Goodrich aviation products

EDITORIAL

Defense Reorganization Plan

The Defense Department reorganization plan submitted to President-elect John F. Kennedy is a basically sound approach to one of the most critical problems facing the nation. Sen. Stuart Symington (D.-Mo.), who headed the group, has a background in modern defense problems matched by few people in active public life today. All of his conferees also have been seasoned by practical experience in trying to run various parts of the Defense Department machinery in the postwar years.

This defense reorganization plan is aimed at molding a defense establishment capable of coping with the problems of today and tomorrow in contrast to the earlier postwar efforts that were basically aimed at perfecting the defense machinery to correct the past errors revealed by World War II. It is a forward-looking plan that recognizes that the basic problem now facing our defense establishment is time. It is this time factor, originating in the fantastic advances in propulsion and compounded by the technical pace of Soviet military technology, that is the key to the success or failure of every phase of the defense effort. The committee's report expressed this salient point extremely well in the following language:

- **"First is the unprecedented** strategic value of time—the ability to react instantly against aggression in this nuclear-space age. In World Wars I and II our country had at least 18 months to build and mobilize its defenses. If there should ever be a World War III, we would be fortunate to have 18 min. to react.
- **"Second is the crucial time element** in the United States vs. Soviet arms race—the need for early selection among alternative weapon systems and for shorter lead times between conception and use.
- **"Third is the effect of time** on defense cost. Regardless of how much the people of this country spend, they cannot buy time. Yet we tend to forget the costly effect of building weapons which have become obsolescent as a result of delay.
- **"Only by giving full recognition** to these all-important time factors can the defense establishment of the United States be strengthened in a meaningful way."

Civilian Cut Proposed

The Symington recommendations strike straight to the heart of the delay problem in the defense structure which is in the vast overlay of civilian secretariat that has been added to the office of the Secretary of Defense in the past six years. It seeks to leave virtually intact the operational activities of the military services themselves and does not recommend a single service with single uniform and single promotion list.

We strongly believe that the first and most effective attack on delay can be made at the level on which the Symington group has taken aim. This superstructure of civilian secretariat with its surrounding complex of ad hoc committees ad nauseam has been the principal cause of stretching out an already complex decision-making process in a period when galloping technology made compression of this process more vital than ever before. Only when this bureaucracy was circumvented by special management techniques such as the Air Force's Ballistic Missile Division, the Navy's Polaris special projects office or the unique, acidulous techniques of Vice Adm. Hyman Rickover has new technology flowered into major weapon systems in sufficient time to be militarily effective. It may be politically unpalatable for the incoming Administration to abolish 22 high level jobs in the Defense Department secretariat that normally would be available to "deserving Democrats" as a reward for political services. But this may be a good yardstick by which to measure just how earnest the new President will continue to be about solving the basic defense problems.

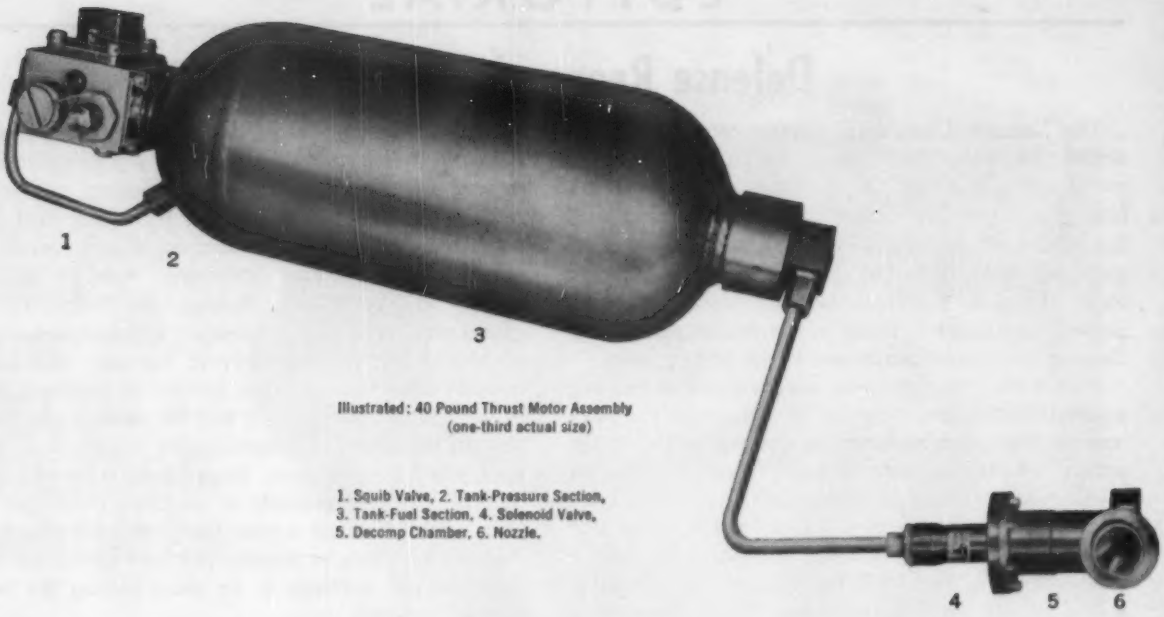
Facing Technical Problems

The addition of a special assistant to the Secretary of Defense for Arms Control is another step in the right direction. Hitherto, the problems of disarmament have been approached in a vague aura of moralistic cant without any regard for the very real technical problems any genuine effort to achieve this goal would involve. This new post could make a tremendous contribution toward developing technical methods of ensuring real enforcement of arms control agreements and guarding against this nation stumbling into disastrous technical pitfalls such as could easily result from unrealistic nuclear test ban agreements.

Any measures than can transform the Joint Chiefs of Staff from a debating society into an over-all strategic planning and decision-making group will also contribute toward a better defense posture. There are many other aspects of the Symington group's proposals that deserve fuller discussion than this space permits and we know there will be no lack of public debate on these proposals in the ensuing months. Heavy fire is certain to be directed against them and any other programs with similar aims by the military mossbacks and the political logrollers who will fight bitterly to preserve personal prerogatives regardless of the cost.

We predict that these perennial snipers at attempts to modernize the Defense Department machinery will find surprisingly little public support in this debate. The American people are pretty well convinced of the necessity for streamlining and modernizing our defense establishment in keeping with the technological pace on which it must be based. They are growing more and more intolerant of the waste, delay and self-seeking service sniping that already has been tolerated far too long.

—Robert Hotz



Illustrated: 40 Pound Thrust Motor Assembly
(one-third actual size)

1. Squib Valve, 2. Tank-Pressure Section,
3. Tank-Fuel Section, 4. Solenoid Valve,
5. Decomp Chamber, 6. Nozzle.

REACTION CONTROL SYSTEMS BY KIDDE are highly reliable, now in production. Today being used on the NASA Scout, Air Force Thor, and the Air Force HETS, they are low in cost, light in weight, highest in performance. Kidde systems use mono-propellant, bi-propellant, cold gas, or solid fuels. Thrust motors from 2 to 600 pounds. For repeatability, response, and reliability in reaction control equipment, Kidde can serve you best! Write to Kidde today outlining your reaction control requirements.

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WHO'S WHERE

Honors and Elections

J. V. Naish, president of Convair Division of General Dynamics Corp., has been elected chairman of the board of governors of the Aerospace Industries Assn. for 1961. **H. M. Horner**, chairman of United Aircraft Corp., was named vice chairman, and **Orval R. Cook** was re-elected president.

William J. Mitchell, vice president of traffic and sales for Bonanza Air Lines, has been elected president of the Air Traffic Conference, a division of the Air Transport Assn., for 1961. Elected vice presidents of the Conference: **William L. Morrisette** of Eastern Air Lines and **C. Gordon Brown** of Piedmont Airlines.

Julian I. Palmore, III, a Cornell University senior, has been granted the $1,000 American Rocket Society-Chrysler Corp. award for his design of a space vehicle which, when landed on the moon, would radio information about the nature of the lunar surface back to earth.

In the Front Office

Dr. Jerome B. Wiesner, a director of Sprague Electric Co., North Adams, Mass., and **Dr. Jerrold Zacharias** retained as a consultant. Dr. Wiesner is director of Massachusetts Institute of Technology's Research Laboratory of Electronics, and Dr. Zacharias is a professor of physics at MIT.

Dr. Lloyd V. Berkner, president, Graduate Research Center, Dallas, Tex. Dr. Berkner, formerly president of Associated Universities, Inc., will be succeeded by **Dr. Leland J. Haworth**, vice president of AUI and director of the Brookhaven National Laboratory, as acting president.

Joseph E. Callahan, commercial vice president, Cleveland Pneumatic Tool Division, Cleveland Pneumatic Industries, Cleveland, Ohio.

Winton S. Smith, vice president-marketing, and **Eugene T. Ferraro**, vice president-customer services, Kearfott Division of General Precision, Inc., Little Falls, N. J.

Canadair, Ltd., Montreal, Canada, has appointed the following vice presidents: **C. F. Fincham**-military relations; **K. H. Larsson**-commercial sales outside America; **J. A. Morley**-North American commercial sales; **G. C. Keefer**-administration.

George H. Mettler, a vice president, Textron, Inc., Providence, R. I. **Charles D. Brown** succeeds Mr. Mettler as president of MB Electronics, a division of Textron Electronics, Inc.

Walter Heuer, vice president of Varig Airlines' International Division.

Lt. Gen. Patrick W. Timberlake (USAF, ret.), corporate vice president of Northrop, will head the company's International Division, succeeding **J. G. Nettleton**, who has resigned to accept a position with International Telephone & Telegraph Corp.

Lt. Col. William J. Nelson, chief, Anti-Missile Missile and Space Defense Office, Army Rocket and Guided Missile Agency, Huntsville, Ala., succeeding **Lt. Col. Claude C. Young**, who will report to Korea for duty.

(*Continued on page 156*)

INDUSTRY OBSERVER

► RVX-2 re-entry vehicle program will evolve into a program called Arc, for advanced re-entry concepts, to study maneuverable nose cones. Atlas-boosted Arc will basically be an RVX with fins and will use a number of different shield configurations. Lift/drag ratio will be 0.5-0.7, and both parachute and landing skid recovery for water and ground landing will be tried. Arc will be unmanned, but successor vehicles may be piloted.

► **Development of a reconnaissance satellite providing a very high resolution pictorial image is being considered by Air Force. It would carry a 40-ft. focal length camera capable of distinguishing 1-ft. long objects from an orbital altitude of 250-300 naut. mi.**

► Second USAF-Lockheed Samos reconnaissance satellite is tentatively scheduled to be launched before the end of this month from an Air Force pad at Navy's Pt. Arguello, Calif., facility. First Samos launch failed to put the payload into orbit last October. Next Midas infrared early warning satellite test flight is scheduled for mid-January.

► **Proposals from four contenders for Project Surveyor—North American Aviation, McDonnell Aircraft, Space Technology Laboratories and Hughes Aircraft—are due Dec. 15. Contract award for the National Aeronautics and Space Administration soft lunar landing vehicle is scheduled for late next March.**

► USAF's proposed Positive Control Bombardment System (AW Dec. 5, p. 26) is being investigated under Study Requirement 199A as a part of Defense Department Ballistic Missile Committee's general category of advanced weapon system studies, which are grouped under SR-199. These bombardment satellites would be put into orbit by the USAF-Martin Titan II.

► **Proposed USAF global communications satellite known as Project Csar (AW Dec. 5, p. 26) is being studied under SR-178, issued last February. Aimed at a highly reliable strategic system to facilitate alert and reaction communications, Csar would weigh 3,800 lb., use solar cells for power and be operational by 1965. Atlas-Centaur is the probable launch vehicle.**

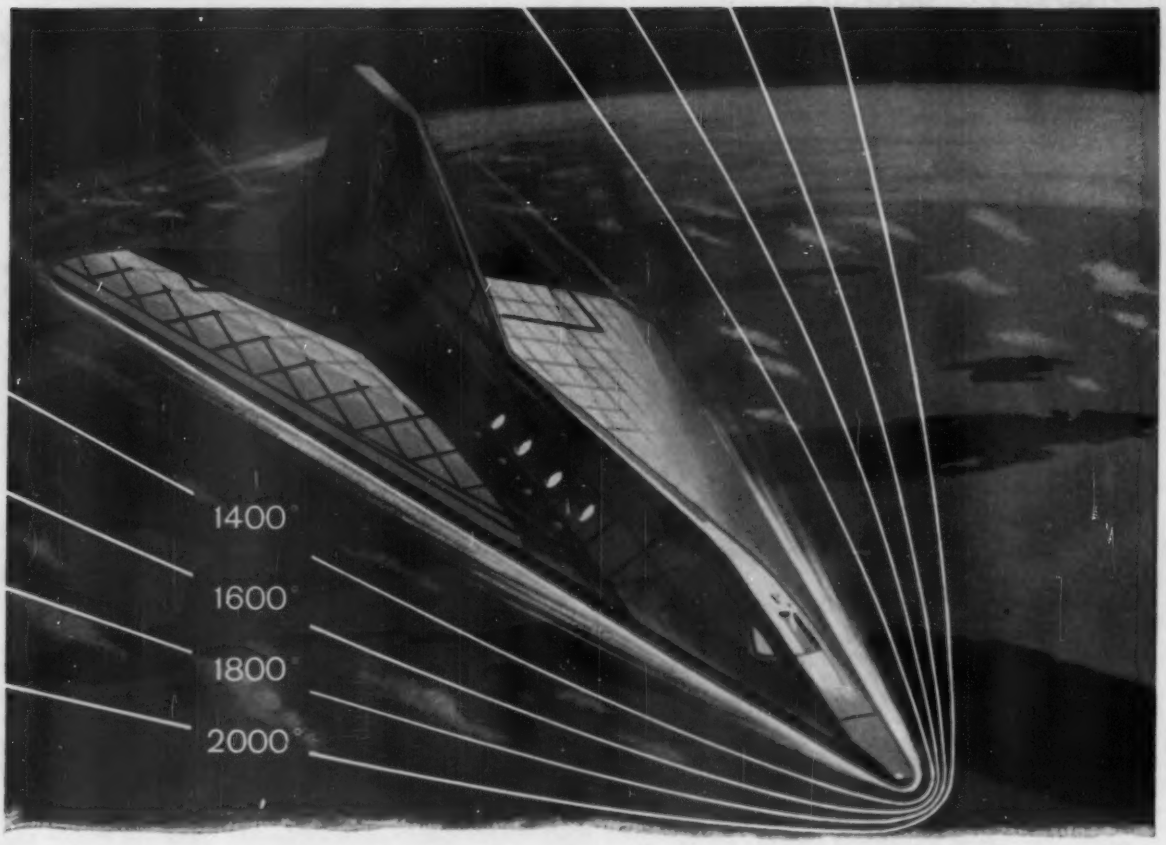
► Breguet is studying a smaller version of its 940 STOL project to meet a new French air force competition for a light STOL transport (AW Nov. 14, p. 23). Designated the 945, the aircraft would use the blown-wing principle and would be powered by two Turbomeca Turmo IIID free turbine engines operating four propellers.

► **Hughes Aircraft has delivered its first Mobot, an underwater robot carried to its operational site by a hydrocopter which operates in water the same way a helicopter flies in air. Mobot has articulated, remotely operated arms with tools at the extremities for performing various jobs. Hydrocopter is three-bladed, driven by underwater reaction propulsion units near the blade tips.**

► Lockheed's California Division is building a company-funded prototype STOL aircraft and an improved version of the prototype helicopter which was destroyed in a crash last spring during a test flight near Newhall, Calif.

► **Physiological instrumentation for X-15 pilots is built into a small package mounted behind the cockpit and connected through his suit to sensors on or near the pilot. Pack was developed by North American Aviation and measures differential pressures between cockpit and suit and between suit and helmet, as well as body surface temperature, electrocardiogram and respiration rate.**

► Company-funded study of three Polaris mobile launch concepts under way at Puget Sound Bridge & Dry Dock Co. includes truck, rail and river-launch systems. Lockheed subsidiary's study is for a Polaris-type North Atlantic Treaty Organization ballistic missile.



Atmospheric Skin Diver... 1980 Style

Double-walled honeycomb panels of HAYNES alloy No. 25 may form the "skin" of a rocket-propelled space glider, predicts a major aircraft company. Already successfully tested, these panels are designed to withstand the terrific temperatures generated as the glider dives back into the earth's atmosphere.

To safeguard the plane's 30 passengers and crew from this blazing re-entry heat, its whole skin, except for leading edges and tail surfaces, will be made of the HAYNES alloy No. 25 panels. Beneath these, a layer of thermal insulation. And liquid circulating through inner walls and airframe will lose excess heat to water to be expended as steam.

Research indicates that a "skin" of this basic type is highly practical. And it seems certain that many other tough, heat- and erosion-resistant HAYNES alloys—some already proved at 2,000 deg. F. and above—will also be aboard.

Whether investment- or sand-cast, rolled, wrought, vacuum melted or air melted, there's a HAYNES high-temperature alloy to meet your needs.

Engineers discuss double-wall test section of space-plane skin with a honeycomb surface panel made of HAYNES alloy No. 25, designed to withstand intense heat of re-entry.

Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y.

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Washington Roundup

New Targeting Plan

First unified strategic targeting plan prepared by **the recently created tri-service targeting unit** has been approved by Defense Secretary Thomas S. Gates, Jr. Although Gates does not consider the plan perfect, he wanted it completed before President Eisenhower leaves office in January.

The target assignment plan takes effect Apr. 1. It gives first priority for delivery of weapons to Strategic Air Command's bomber fleet, where it has been, even though most of the fleet is rapidly becoming obsolete. A realistic appraisal of current intercontinental missile capability kept ICBMs from the priority list. They have been assigned subordinate roles along with other delivery systems farther down the list.

Gates' principal objection was to the assignment of several weapons to one target. Although one bomb would paralyze a city, 10 are assigned in order to attain a theoretical damage of 97%. Gates also objected to the concept of ignoring the problem of fallout over friendly territory.

Leading contenders for Gates' job in the Kennedy cabinet are believed to be Thomas J. Watson, Jr., Roswell Gilpatric and William Foster. Robert Lovett, a Republican who held the job under a Democratic Administration, has declined on the grounds of ill health.

Watson, president of International Business Machines Corp., was a senior Air Force pilot during World War II with the rank of lieutenant colonel. He is one of five Republicans who were critical of the Eisenhower Administration's Fiscal 1961 defense budget and policies.

Watson told Congress last spring that "our national goal should be clear superiority over the Soviet Union in all possible areas, and we should believe enough in democracy so that we will not be reluctant to fully enter the contest."

Gilpatric is chairman of the board of Aerospace Corp. and a former Air Force under secretary, and Foster headed the Gaither Committee, whose report urged a great increase in the defense effort.

Frank Pace, chairman of the board of General Dynamics Corp., will not take the defense post as many have speculated, but is expected to accept a major ambassadorship.

Military Candidates

Gen. Curtis Lemay, Air Force vice chief of staff, is expected to retire instead of moving into the top job, which may be open very early in the Kennedy Administration. Best bets for the top job, even though they do not stand at the top of the seniority list, are Gen. Thomas S. Power, strategic air commander; Gen. Lawrence Kuter, North American air defense commander and Lt. Gen. Bernard A. Schriever, air research and development commander.

Adm. Arleigh Burke, who has been chief of naval operations for three terms, probably will be replaced long before his scheduled retirement in June. Leading prospects to succeed him are Vice Adm. John T. Hayward, deputy chief for development; Adm. James S. Russell, now vice chief; and Vice Adm. W. F. Raborn, director of the Polaris program.

President Eisenhower, Secretary Gates and Budget Director Maurice Stans last week held what may be the last discussion of the Fiscal 1962 defense budget before it is frozen. The total now looks as if it may be no more than $40 billion.

David E. Bell, 41, named by President-elect John Kennedy as his new budget director, already has opened an office at the Budget Bureau. Bell served as a White House assistant and Budget Bureau examiner and analyst for seven years in the Truman Administration.

Critical Budget Action

Navy's Missileer aircraft appeared to be out of the Fiscal 1962 budget last week but the final decision was being made at the White House. If Douglas loses the Missileer, there is a strong possibility that it would get the MATS interim jet cargo aircraft contract to help ease employment problems at Long Beach (see p. 36).

This in turn could means that Boeing would be chosen to build the tactical Air Command STOL fighter-bomber. But the interim jet also was the subject of a White House conference late last week, and the STOL fighter undoubtedly came into the same conversation.

North Carolina Gov. Luther H. Hodges, nominated as Kennedy's Secretary of Commerce, will be a key man in two programs affecting aviation which will be pressed by the Administration to counter the present unfavorable balance of payments.

They are the increase of aircraft exports and promotion of foreign travel to the U. S. The travel balance is now heavily the other way, with U. S. citizens spending some $2 billion a year, almost $1 billion more than foreign travelers spend on U. S. carriers and in this country.

—Washington Staff

Space Virtues of Liquids, Solids Debated

Companies renew battle at Rocket Society meeting; emphasis shifts from missiles to launch vehicles.

Washington—Rocket engine manufacturers took advantage of the American Rocket Society's Annual Meeting here last week to renew the old battle of liquid propellants versus solid propellants. But this time, the applications at issue were large space vehicles instead of ballistic missiles.

The liquid propellant proponents claimed that by the mid-1960s liquid rocket engines will be capable of placing payloads "in the order of hundreds of thousands of pounds" in earth orbits and of carrying "tens of thousands of pounds" of payloads to escape velocity for lunar round trips and planetary orbiting. Solid propellant rocket engine manufacturers said that even conceding large liquid engines the head start they already have, solids could do the same thing in the same time and at a significantly lower dollar-per-pound payload cost.

Richard C. Mulready, Pratt & Whitney project engineer in charge of development of the liquid oxygen-liquid hydrogen LR-115 Centaur rocket engine, reported that the engine has met or exceeded all performance requirements to date. The engine has fired continuously for 5½ min., the limit of test stand propellant tank capacity.

A program is now under way on Pratt & Whitney's vertical test stand in West Palm Beach, Fla. to simulate the Centaur vehicle system by testing the propellant supply system with a dual engine installation. The first Centaur vehicle is scheduled to fly in 1961 using an upper stage powered by two LR-115 engines. National Aeronautics and Space Administration has authorized Pratt & Whitney to upgrade the LR-115 from 15,000 lb. thrust to 17,500 lb. thrust.

F-1 Engine Progress

Rocketdyne's David E. Aldrich and Dominick J. Sanchini reported that the single chamber, 1.5 million lb. thrust, liquid propellant F-1 engine under development for NASA will begin its first complete engine tests early next year. Preliminary flight rating test of the engine will start in late 1962 and end in early 1963.

By taking advantage of the engine clustering technology now being developed by NASA on the Saturn, they said, it should be possible to launch a cluster of six F-1 engines capable of producing 9 million lb. thrust by the mid-1960s. Coupled with suitable high energy, upper-stage, liquid rocket engines, Rocketdyne estimates the 9 million lb. thrust booster will be capable of performing these missions:

- **Placing a 400,000-lb.** payload in a low earth orbit.
- **Putting a 130,000-lb.** payload into a 24-hr. orbit.
- **Putting a 90,000-lb.** payload into a Mars orbit.
- **Carrying out a manned** lunar landing and return with an earth-landing weight of approximately 20,000 lb.

The F-1 presently is designed for a propellant combination of liquid oxygen and RP-1. But Aldrich, program manager for the F-1, told AVIATION WEEK that preliminary operations engineers are studying the high energy liquid oxygen-liquid hydrogen combination. The use of this combination for the F-1, he said, would raise performance about 40 sec.

The problem of developing a large injector, perhaps the biggest development problem with the F-1, has been solved, Aldrich said. From several injector tests run at 1 million lb. thrust levels and above, two stable injector configurations have now evolved and will be further evaluated until one is selected. First tests of the full-scale F-1 turbopump took place last month. Five feet long and four feet in diameter, the direct-drive turbopump weighs 2,500 lb., develops 60,000 hp. and can move three tons of propellant per second.

Aldrich said that development of the F-1 engine is on schedule. Extension of the F-1 program from 46 months to 50 months was explained as the result of a reallocation of Fiscal 1960 funds which put some F-1 money into other NASA projects considered more urgent. As the F-1 program now stands, it will come to an end with the rating test in 1963, unless NASA awards Rocketdyne a new contract for further development or production of the engine.

Before much more money is put into the development of large, liquid propellant rocket engines, Grand Central Rocket Co., Aerojet-General Corp. and Thiokol Chemical Corp. hope to sell NASA on the advantage of large solid propellant boosters. Awarded contracts by NASA (AW Sept. 19, p. 28) for preliminary design studies of large solid boosters in the 1-million lb. and 7-million lb. gross vehicle weight class for both orbit and escape missions, the three companies expect to submit their final reports next March. The 7-million lb. class studies subsequently were increased to 9 million lb.

First indications of what might be expected in these reports were given at the ARS meeting by H. L. Thackwell, Jr., senior vice president of Grand Central, in a report co-authored by Grand Central's Ralph M. Pierce. In his report, Mr. Thackwell described three different solid propellant vehicles: a three-stage vehicle which would put a 30,000-lb. payload into a 300 mi. earth orbit, a four stage vehicle which could put a 100,000-lb. payload in orbit or escape with a 22,000-lb. payload; a five stage vehicle which could orbit a 250,000-lb. payload or carry a 60,000-lb. payload to escape velocity.

All three vehicles would be constructed of essentially identical, cylindrical solid propellant rocket motor segments. It was assumed that the segments, which would be bolted together at the launch pad, would contain a conventional, case-bonded, radial-burning solid propellant grain with a sea level specific impulse of 245 sec. at 1,000 psi. All vehicles were to be constructed from two basic motor configurations: Design I, a single solid propellant segment with head cap nozzle; and Design II, a five segment motor slightly taller than the Atlas.

Larger Solid Vehicle

The three-stage Type A vehicle described by Thackwell consists of a Design I motor third stage, a Design II motor second stage and a cluster of four Design II motors for the booster. The booster motors are banded together by rigid bulkheads secured to the top and bottom motor attachment flanges. Jet vanes are used for thrust vector control in the booster, while small auxiliary rocket motors, housed around the outside of the nozzle throat section, are used in upper stages.

To launch a 30,000-lb. satellite, Thackwell estimated that his Type A vehicle would weigh 2,471,000 lb. at takeoff. He said costs, including everything from research on, would run $204 per pound of payload in orbit for 100 vehicle flights to $740 per pound for 10 vehicle flights. By comparison, recent estimates given for the Saturn range from $500 to $700 per pound of payload in orbit. Assuming adequate funding and a Jan. 1, 1961 starting date, Thackwell said, Type A vehicles could begin routine flights on Jan. 1, 1965.

The four-stage Type B vehicle en-

visioned by Thackwell would consist essentially of a Type A vehicle with a new first stage made up of eight Design II motors clustered together. Takeoff weight would be 6,250,000 lb., and payload costs would range from $117 per pound for 100 flights to $350 per pound for 10 flights. Type B vehicles could begin routine flights by July 1, 1965, he said.

The five-stage Type C vehicle would be the Type B vehicle on top of a cluster of 16 Design II motors. As in the case of Type B, the second stage, the first stage in the preceding design, would switch from jet vanes to auxiliary motors and would use nozzles with larger expansion ratios. Takeoff weight of Type C vehicle would be 13.5 million lb., and payload costs would run from $110 per pound for 100 flights to $288 per pound for 10 flights. Routine flights of Type C vehicle, Thackwell said, could start on July 1, 1966.

Grand Central Studies

NASA's contract to Grand Central covers only preliminary design study on the 1 million lb. weight vehicle. But Thackwell told AVIATION WEEK that Grand Central is carrying out a study on the 7-million lb. vehicle with company funds. The NASA contracts which call for specific designs of first stage boosters also ask for general designs of high energy liquid upper stages similar to the liquid oxygen-liquid hydrogen engines now under development in order to get a realistic picture of over-all vehicle performance from the three contractors.

Thackwell feels however, that solids would offer significant advantages in these upper stages as well. Thrust level control, he believes, can be obtained with solids, where needed, by going to a hybrid motor in which a liquid oxidizer is used for thrust modulation.

The NASA study is likely to turn into a hardware contract, Thackwell feels, that could produce a booster competitive with the Saturn booster. He said that a cluster of three two-segment solid motors would be equivalent to the Saturn. It would be somewhat shorter than Saturn and not quite 20 ft. in diameter. A cluster of three five-segment motors, he added, would provide a 40% increase over Saturn booster performance.

Grand Central's preliminary design study for NASA is believed to envision a booster for the proposed 1-million lb. vehicle that would produce 2.2 million lb. thrust, assuming a 45-sec. burning time. The booster would use the company's own polybutadiene type of propellant, called polycarbutene, and could be ready for preliminary flight tests in 18 months, Thackwell said.

NASA to Study Unconventional Rockets

Washington—Contracts to study use of unconventional high-thrust liquid engine-vehicle designs will be awarded early next year by the National Aeronautics and Space Administration to determine whether such approaches as plug nozzles and simplified structures can reduce the cost of launch vehicles.

Request for design study proposals calls for survey of feasible designs ranging in thrust from 2 million to 24 million lb. Invitations to bid on the study have gone to industry, and bids are due Dec. 23. Vehicles are called unconventional because NASA wants evaluation of unusual nozzle and chamber designs which could result in cheaper and more reliable vehicles than the large boosters under development.

The program is a continuation of a series of studies on the entire range of large booster potential. NASA is looking at large solid propellant vehicles with thrust levels up to 21 million lb. (AW Sept. 19, p. 28) and at alternate concepts for the Nova configurations (AW Oct. 10, p. 26). Flight model 50,000-lb. thrust plug nozzle engine is being developed for NASA by General Electric Co.

The pending study contract will consider hydrocarbons and liquid hydrogen fuels. It will cover a two-part design study, consisting of these tasks:

- **Establish the advantage in cost and reliability of unconventional liquid engines and and engine-vehicle combinations. This requirement includes preparation of an array of possible designs, selection of the most promising design plus estimates of the cost of a research and development program, and of the cost of test and production facilities for a six-year manufacturing program of 25, 100 and 400 engines.**
- **Analyze engineering and program components, including chamber pressure, nozzle configuration, area ratio, thrust vector control, valving, analytical and experimental programs required to detail performance parameters, and cost factors in research and development, test and production.**

First phase is expected to be completed four months after contract award, and the second in the following six months.

Alternative in the broad study comes if significant savings and reliability cannot be established for unconventional first stage engines. Program objectives then would be shifted to second stage studies.

Bidders are asked to specify their qualifications and experience in their proposals by including their methods of approach, project plan, personnel and facilities available, subcontractor organization and computer availability.

Thiokol and Aerojet-General generally agree with Grand Central that significant cost savings could be obtained with large solid propellant space boosters, but they differ on some other significant details.

Thiokol Program

About a month ago, Thiokol, which had the study contract for the 7-million lb. vehicle, was asked by NASA to change this to a 9-million lb. vehicle. Booster thrust, which was approximately 15 million lb. originally, now reportedly has gone up to 18-20 million lb. Thiokol is evaluating both the segmented motor approach and on-site loading, according to Redstone Division project manager W. L. Berry.

While the requirement for high energy liquid motors for the upper stage was spelled out by NASA, Berry said that even if given a free choice in the matter, Thiokol would probably accept a liquid engine in at least the last stage with motor technology at its current level of development. At the same time, he said, Thiokol is studying hybrids at both its Redstone and Reaction Motors divisions with emphasis on hypergolic propellant combinations and on use of liquid oxidizers in thrust level modulation.

In its segmented motor approach, Thiokol researchers currently appear to favor joining the sections together in a manner similar to that of a torpedo joint, in which the bolts are hidden in an indented V instead of protruding.

Given complete freedom in the choice of upper stage engines, Berry estimated that Thiokol could produce a 9-million lb. vehicle at 1/15th to 1/20th the cost of a comparable all-liquid vehicle. Even without freedom of choice in the upper stages, he believes it can be done at ¼ to ⅓th the cost. If given the go-ahead now, he said, Thiokol could have a vehicle in the air sometime in 1963.

On its NASA contract, Aerojet was asked to do a preliminary design study on both the 1 million lb. and 7 (now 9) million lb. vehicle. Aerojet and Grand Central also have Air Force contracts for the development of a solid propellant rocket with a total impulse of 20 million lb.-sec. This contract will culminate in the firing of a full scale (100,000 lb. of propellant) motor. First firing of small scale (40,000 lb. of propellant) motors is expected to take place in the next 30-40 days, and the first full scale motor firings in about four months.

This Air Force program involves seg-

mented solid motors and is complementary to the NASA study, Aerojet's Dr. Ernest R. Roberts told AVIATION WEEK. It will be a relatively simple matter, he feels, to increase the number of segments and step into the higher weight and thrust class of vehicles for NASA. However, as part of its NASA study, Aerojet also is investigating on-site loading. At this time, Dr. Roberts said, on-site loading definitely appears uneconomical, at least for the 1-million lb. class of vehicles.

In its big solid booster programs, Aerojet is working with motor segments that have an aspect ratio close to one and use polyurethane propellant. Both segment diameter and weight are limited for transportation reasons. Segment weight is believed to be approximately 70,000 lb. and diameter 120 in. Segments are interlocked by pulling a wire.

Cluster Pattern

While no final designs have been set, indications are that the big Aerojet boosters will run perhaps six segments per motor and no more than seven motors to a booster cluster. A solid booster comparable in performance to the Saturn would probably be the limit for a single segmented motor, Dr. Roberts said. It will be possible to obtain a total impulse of 100 million lb.-sec. with a five segment motor.

Aerojet is working on hybrid rocket motors under a contract from the Navy Bureau of Weapons. Dr. Roberts feels that this work is still in a rather embryonic stage and that whatever advantages such a system proves to have will have more value for volume-limited missile systems than for space vehicles, although he does not rule out its potential value for thrust modulation and on-off control in upper stages.

Fuel Combination

The best large space vehicle that can be developed today, Dr. Roberts believes, will prove to be a combination of liquid and solid propellant stages. In the upper stages where every pound is critical, the higher specific impulse and mass fraction of the liquids—even where it is only fractional—makes them more attractive, he said.

At the same time, he said, solids will probably always prove more economical for the first stage and possibly for the second. Except for special missions, he now concedes third stages and above to the liquids.

Dr. Roberts estimates that solid motors in the first stage of these large vehicles will reduce payload delivery costs attainable with a large liquid booster by 20-30%. Moreover, he said, it is possible to produce a solid propellant booster in the Nova class by sometime in the 1963-64 time period.

ARS Coverage

American Rocket Society's 15th annual meeting was covered by an Aviation Week team headed by Editor Robert Hotz and consisting of David A. Anderton, Philip J. Klass, Michael M. Yaffee, Edward H. Kolcum, Larry Booda, Evert Clark and Craig Lewis.

Lockheed Designs New Capsule For Orbital Chimpanzee Tests

Washington—Advanced bio-medical capsule (ABC) planned for two-day orbital exposure of a 50-lb. chimpanzee has been carried through design and mockup by Lockheed Missile Systems Division.

The self-contained capsule could be modified and expanded to carry a human subject. It could also be used with multiple subjects smaller than the chimpanzee.

Mockup was shown for the first time at the 15th annual meeting of the American Rocket Society here. The model is the product of a feasibility contract funded by the Bio-Astronautics Projects Office of the Air Force Ballistic Missile Division. Major aim of the proposed complete program is to "fly earliest, fly cheapest" to get bio-medical data on a large subject in a space environment.

Contingency of Funds

Further development through hardware and flight-testing is waiting second-phase Air Force funding. Flight testing is also contingent upon availability of the Atlas-Agena configuration for a launcher, with its second-stage Agena expanded to a 6 ft. diameter package.

The self-contained animal capsule provides a complete life-support system and ample test instrumentation for physiological and psychological monitoring in a cylindrical package about 3 ft. in diameter and slightly more than 4 ft. long. It weighs 350 lb. complete and would be mounted horizontally in the Agena when the Atlas-Agena is erected before launching. Only external 28-v.d.c. power need be supplied—the capsule is otherwise self-sufficient. All components are off-the-shelf.

Launching with the advanced Atlas-Agena, similar to the configuration for Samos I, gives flexibility of orbital path choice so that subjects could be exposed at altitudes up to 2,000 mi. for best experimental results. If radiation densities above the earth are measured prior to the animal launching, the subject could be orbited at the altitude for maximum exposure or controlled exposure to specific types of particles.

Recovery of the capsule will be patterned after the successful Discoverer technique, using Lockheed C-130 aircraft for the air-snatch attempts.

Major aim of the ABC satellite is to obtain physiological and psychological data on the animal's response to a space environment. Basic instrumentation and control units monitor and maintain the oxygen atmosphere in the capsule and measure its temperature, humidity, sound level and odor.

Physiological instrumentation on the animal mixes both external sensors and internally implanted sensor-transmitter units. Psychological data comes primarily from a bank of simple pattern-matching tasks and a battery of colored lights which the animal is supposed to switch off selectively.

Data Transmission

Test data taken during flight would be transmitted to ground stations by 150-data point FM/FM telemetering equipment separate from the telemetry in the Agena stage. In addition, data would be recorded by an endless-loop tape recorder. A still TV photo system would be used to photograph the animal's facial expressions, with pictures transmitted by a UHF television transmitter.

The animal subject is to be prepared two days before the planned shot, and after a period of acclimatization to the restraining suit, would be strapped to the couch just before the launching. Couch is palletized so that the animal can be placed in the capsule shortly before flight, already wired and ready to be connected to instrumentation pickup leads.

Extra hand and footgrips are built into the couch so the animal has something to grip during its period in the flight. Gripping is a simple physical action that apparently provides a feeling of well-being for the animal.

Electrical heating, thermostatically controlled, is used to maintain capsule temperature in orbit. During re-entry, cooling is done by evaporation and by radiant exchange.

Feeding of the animal is done mechanically, by time-opening a panel in the center of the instrument panel. Food is a gelatinous mix to include water, and it supplies 1,000 calories and 500 cu. cm. of water per day at four-hour feeding intervals.

Nations Approve Space Center Talks

Geneva—Initial organizational meeting of an Intergovernmental Preparatory Commission charged with establishing an 11-nation European space research center, may be held in Paris by early spring.

Establishment of the commission followed a five-day meeting of scientists at the European Organization for Nuclear Research in the suburb of Meyrin.

The Paris meeting will be scheduled one month after at least six governments representing 70% of the commission's $200,000 budget give their final approval. Observers here hope that this goal may be achieved within three months time.

Scientists from five nations—Great Britain, Belgium, The Netherlands, Norway and Sweden—whose contributions would represent approximately 30% of the commission's over-all budget request already have signed the Meyrin agreement establishing the group without reservation.

Representatives of four others—Denmark, France, Spain and Switzerland—signed conditionally, but the pact must be ratified by their respective parliaments before it takes force.

The West German delegation said it had no authority to approve the agreement in any way. Sir Harry Massey, chairman of the Meyrin conference and head of the British National Committee on Space Research, said, however, that the West German government is expected to ratify the agreement within the near future.

Sputnik VI Destroyed

Moscow—Destruction of Sputnik VI—Russia's third "spaceship"—during reentry Dec. 2 has deprived scientists of the opportunity to get lifetime data on the effects of space environment on the two dogs, other animals, insect and plant life carried into orbit.

Telemetery worked normally, transmitting data on animal cardiovascular and respiratory systems and on responses to noise, vibration, acceleration and weightlessness. Television monitoring of the animals plus telemetered data showed their behavior to be nearly normal. Loss of the experimental subjects means Russian scientists cannot trace future effects of past exposure as the subjects age normally.

Official statements said planned experimentation had been completed by noon Dec. 2, Moscow time, when reentry command was sent. Descent did not follow the programed trajectory.

Hughes Signs TWA Financing

Trans World Airlines $300 million financing package finally got the necessary Howard Hughes signatures last week, and lenders met to consider his tender that apparently included a provision for pre-payment of the debt.

Approval was expected. TWA may thus get some of its Convair 880s waiting on the ramp at San Diego into service by Christmas, but interiors on some suffered damage because of exposure to weather and salt water environment. Later airplanes were completed only as far as the airframe and interior equipment was not installed.

Four airplanes were left uncoated with preservative as the result of Hughes sending in his own guards who towed them away from the ramp to an isolated spot at the water's edge. Two were removed subsequently, but the other two, No. 5 and No. 8 airplanes, were damaged by corrosion to the extent that all their CJ805 turbojet engines had to be removed and sent back to General Electric's Evendale, Ohio, plant for overhaul. Roughly 10% of components will have to be replaced.

Hughes signed the agreements under pressure of warnings by holders of TWA's current debt that foreclosure action would begin by the weekend if he did not sign. The package is the original Dillon plan (AW Oct. 31, p. 35) which calls for Hughes to place his 78% stock interest in a three-man trust in which he is represented by one member and the lenders the other two. Hughes named Raymond M. Holliday, Hughes Tool Co. financial vice president, as his representative.

Two alternative plans considered by Hughes were dropped. One proposed by Merrill Lynch, Pierce, Fenner & Smith required more time to perfect than was available, presumably because it involved a change in the status of Hughes Aircraft Co., now held in trust. The other, involving the Crown interests of Chicago and Bank of America, was an interim plan that would have provided for delivery of the Convair 880s but not for payment for the bulk of TWA's Boeing 707 fleet which is owned by Hughes Tool Co.

The preparatory commission itself has been charged with working out details of prospective programs to be undertaken by the space center, a proposed budget for its initial development and operation and recommendations on personnel to staff it as well as the preparation of organizational statutes, membership fees, etc. It also will recommend possible sites for the physical location of the center.

It is hoped that the commission can complete its work within a year and be followed by an European space research organization which will have responsibility for the actual establishment of the space center.

Since two neutral nations, Switzerland and Sweden, are involved in the agreement, representatives at the Meyrin conference stressed that the center would concern itself solely with projects that were of a purely civil, rather than military, nature. The scientists after debate also ruled that the center would make no effort to develop independent booster systems.

Although delegates from Belgium, Italy and The Netherlands urged that the center be given the scope to enter the entire spectrum of space research and development, other delegations felt the development costs to booster systems might drive some of the smaller nations from participation. Costs of putting the center into operation alone are estimated at approximately $70 million. Other countries, notably Great Britain and France, hope to sell the center the booster system it will need to put into orbit the payloads it has developed.

Probable areas of work for the center outlined by the Meyrin conference include satellite vehicles that would study solar radiation and cosmic ray fields, a check on Einstein's theory of relativity and exploration of the exact size and shape of the earth. It also would probe ionospheric scatter techniques, as the U. S. already is doing, to improve communications techniques.

Average national income of the individual member nations during the past three years will be used as the basis of determination of how much each will be expected to contribute to the overall budget. No nation, however, will be asked to contribute more than 25% of the total expenditures. Three largest contributors probably will be Britain, France and West Germany.

Proposals for such a session as the Meyrin conference have been under study for the past year, and a preliminary conference among scientists from several of the nations was held in Paris in June. Invitation to hold the intergovernmental meeting at Meyrin was formally extended by the Swiss government last month.

At the start of the Meyrin conference, only 10 nations were represented by official delegations, with Spain sitting in as an observer. During the course of the sessions, however, it was accepted as a full member. Any future admissions to the group must be unanimously approved by the present 11 members.

Discoverer XVIII Reported in Orbit

Discoverer XVIII was reported in orbit following launch last week from Vandenberg AFB, Calif. First signal from the orbiting satellite was received at Kodiak Station in the Aleutions. Air Force was expected to attempt recovery of the payload.

Orbital period of the 300-lb. satellite vehicle is 94 min., apogee is 450 mi. and perigee is 150 mi.

Discoverer XVIII booster had a refined Rocketdyne NA-11 engine, delivering 165,000 lb. thrust, 10% more than that available from previous Thor engines.

West Germans Drop Jet Transport Plan

Hamburg—Hamburger Flugzeugbau is abandoning its hopes of building the 70-passenger, Mach .9 HFB-314 jet transport because of lack of support from the West German Federal Economic Ministry.

Officials of the firm said last week they have withdrawn an application to the Ministry for a credit guarantee that would have financed development of two prototype aircraft and given West Germany a jet transport of its own design.

The company told the Ministry it was in a good competitive position for the production of a twin-engine, medium-range jet transport when it first made its application for support two years ago, but that it was now far behind the field.

The HFB-314 never progressed beyond the model stage, and Hamburger Flugzeugbau officials estimated they would need orders for a minimum of 100 aircraft before ordering it into production.

No Production Planned For Aerospace Corp.

Washington—Aerospace Corp., the nonprofit firm that will perform systems engineering and technical direction for Air Force ballistic missile and space programs, will never engage in manufacturing, President Ivan A. Getting assured industry at the American Rocket Society's annual meeting last week.

Getting also said Aerospace is aware that the term "systems engineering and technical direction" is a "potentially troublesome" bit of semantics. "We recognize the happy fact of life that industry is very competent in all of the areas of our present space technology," Getting said. "We will not attempt the frustration-provoking exercise of telling the contractor how to do, step by step, tasks they are fully competent to do by themselves."

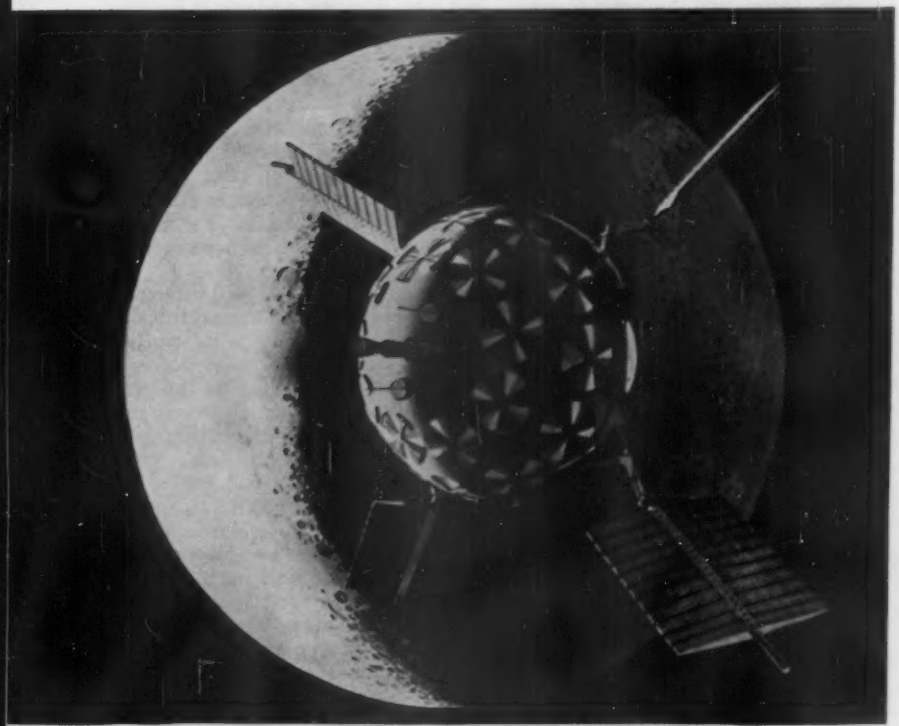
Getting said the company's task divides into the following three main elements:

- **Advanced planning** and systems research. This includes assisting USAF in formulation of new weapon system concepts and preparation of specifications, using ideas originating from any source, and evaluation of both solicited and unsolicited technical proposals. This "initial systems engineering" can be done "objectively by a privileged but non-competitive organization," he declared.
- **Engineering.** This involves integration of associate contractors' designs, resolution of "interface problems," establishing of milestones and supervision of systems tests. Again Getting said that "only a non-competitive organization can approach this task with the necessary objectivity." Aerospace Corp. was created because its predecessor, Space Technology Laboratories, Inc., was never able to attain to industy's complete satisfaction either "the in-fact objectivity that was desired" or "no less important, the appearance of that objectivity."
- **Research.** The company and its staff "must be a part of the scientific community" because it cannot do its other jobs with full effectiveness "unless the impact of advancing science is continuously brought to bear," Getting said.

XLR-99 X-15 Flight

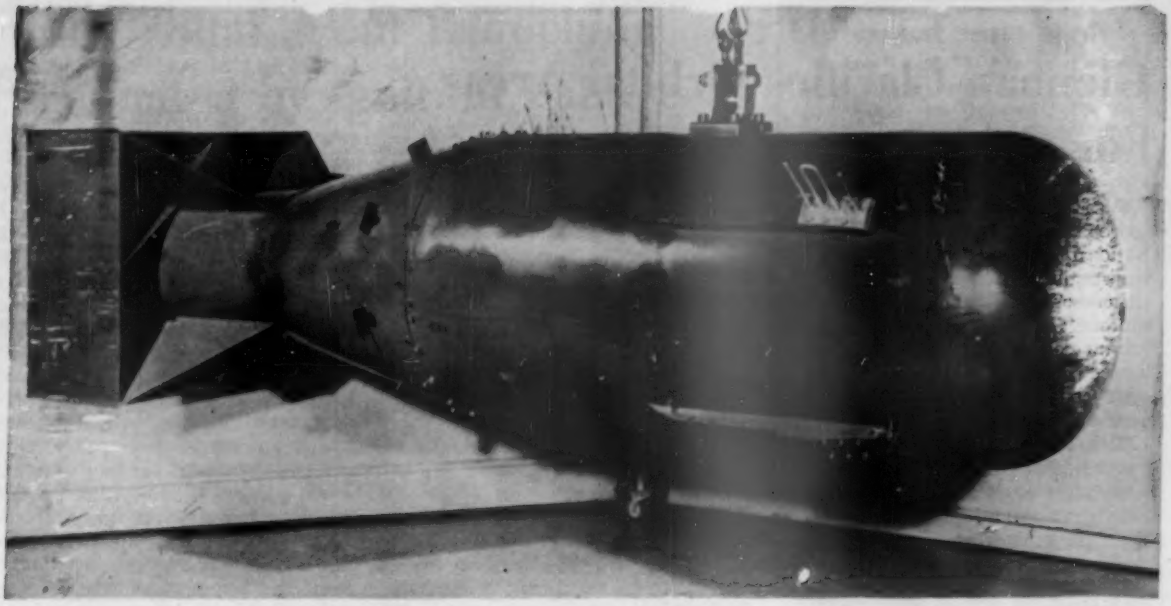
Edwards AFB, Calif.—After completing a third successful flight with the larger, 57,000 lb. thrust XLR-99 engine, the No. 2 X-15 has been accepted by the Air Force for turnover to National Aeronautics and Space Administration in about four to six weeks. This flight completed the North American Aviation demonstration flight portion of the program on the No. 2 aircraft.

During the flight last week, two complete engine shutdowns and restarts were accomplished in the seven-minute powered flight. Most of the flight was at 50,000 ft. altitude with the speed brakes on, after launch from the B-52 mother ship at 45,000 ft. A maximum altitude of 60,000 ft, and a maximum speed of Mach 2.9 were attained. Just prior to engine burnout, pilot Scott Crossfield advanced to full throttle for a few seconds.



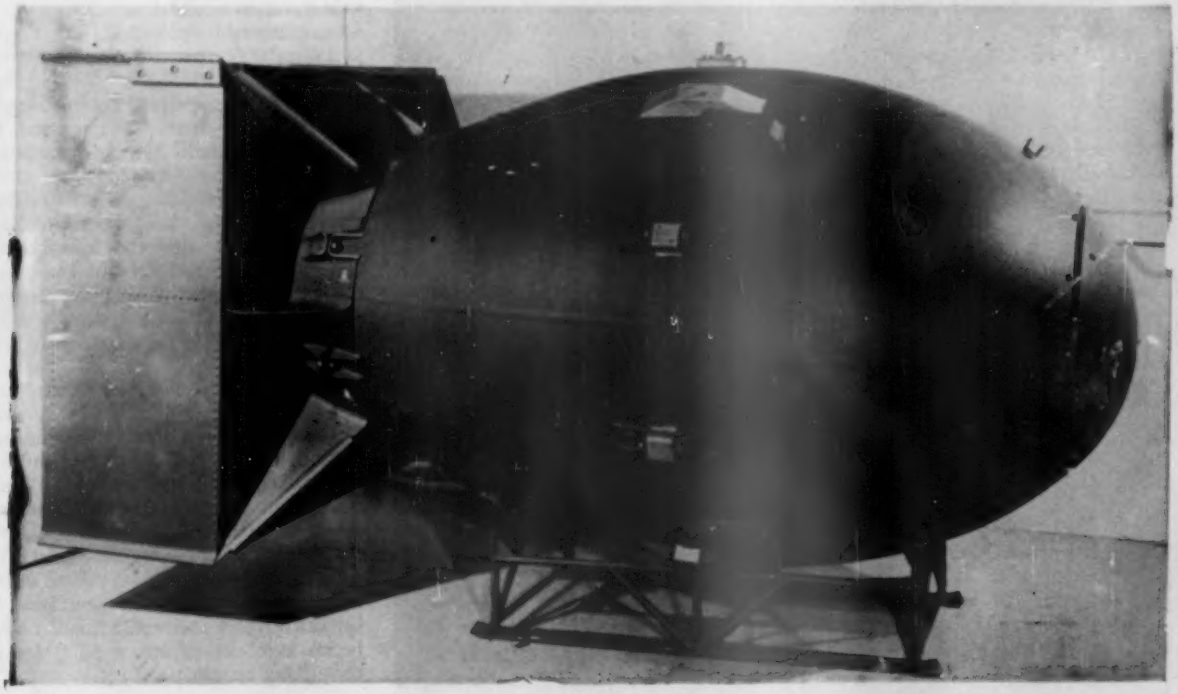
Pioneer VI Set for Dec. 14 Launch

Atlas Able V's Pioneer VI payload is scheduled to be injected into orbit following launch from Cape Canaveral on Dec. 14. Payload will include a new experiment—a solid-state silicon detector devised by the University of Chicago—developed to distinguish protons from electrons and identify proton flux energies in the range of 0.5 to 9 mev. Solid-state detector was not included in previous 388-lb. Pioneer VI payload, which failed to achieve orbit in Sept. 25th firing. Pioneer VI is programed to be put into orbit around the moon with an apolune of 5,700 mi. and a perilune of about 3,800 mi. (AW Sept. 12, p. 56).



First Photos of Atom Bombs Dropped on Japan

Atomic Energy Commission last week released the first pictures of the historical atomic bomb types detonated over Hiroshima and Nagasaki, the first and only nuclear weapons ever utilized in warfare. They killed a total of over 100,000 in the two cities and brought World War II to an end. The Little Boy type dropped on Hiroshima Aug. 6, 1945 (above) was a uranium bomb weighing about 9,000 lb. It was 10 ft. long and 2 ft. 4 in. in diameter. The Fat Man type dropped on Nagasaki three days later (below) weighed about 10,000 lb. and was a plutonium bomb. It was 10 ft. 8 in. long and 5 ft. in diameter. AEC declassified data on the bombs in 1958 (AW Oct. 17, p. 25). The commission, largely on the advice of State Department, has refused previously to release pictures or replicas of the bombs on the grounds that this "would give the appearance of gloating or boasting about the weapons side of atomic energy use" and "would afford an opening for anti-American propaganda around the world." State has been particularly concerned that a pictorial display would be "misinterpreted . . . as a display commemorating the use of the bombs." In announcing the release on the eve of the anniversary of Pearl Harbor instead of the anniversary of their use, AEC observed: "While there is a possibility that this may result in some unfavorable impact upon the position of the United States in the Far East, the Department of State has concluded that possible reaction would be minimized by a release at this time." Rep. Charles Porter (D.-Ore.) and the House Government Information Subcommittee, headed by Rep. John Moss (D.-Calif.), have led congressional pressure for release. Porter has also unsuccessfully urged a display of the bomb types at the Smithsonian Institution. The B-29 Enola Gay that dropped the bombs on both cities is being reconditioned for permanent display at the Institution.



Glennan Clarifies Orbital Areas For Communications Satellites

Washington—Recent move into the active communication satellite field by National Aeronautics and Space Administration is aimed initially at low-altitude orbits of 2,000 to 6,000 mi. In contrast, Defense Department's Project Advent communications satellite is intended for a 22,300-mi. synchronous orbit, but this demarcation is not necessarily permanent.

This was disclosed in a recent letter from NASA Administrator T. Keith Glennan in reply to questions on possible overlap and duplication in the active communications satellite field raised by Vice President-elect Lyndon B. Johnson, chairman of the Senate Committee on Aeronautical and Space Sciences, in a letter to Glennan.

Glennan said the "demarcation is a dynamic one and it must necessarily accommodate rapidly changing developments in technology." Although NASA currently has no immediate projects for hardware development or flight testing at high altitudes, "NASA's plans and research will not overlook the application of such systems to non-military uses."

NASA Agreement

When NASA originally was established, it was agreed that it would pursue passive (reflector) type communication satellites while the Defense Department concentrated on the active type. At that time, both the Air Force and Army had low-altitude orbit, active communication satellite programs. Early this year, Defense Department decided to concentrate on the synchronous orbit, 22,300-mi. communications satellite and to drop the low-altitude orbit projects.

Several years ago the passive satellite was expected to be the most economical type for commercial communications use, but more recently American Telephone & Telegraph Co., and others, have shifted to active types as the more promising.

NASA hopes to initiate its active communications satellite program in the current fiscal year and to continue it with Fiscal 1962 funds, Glennan said. The timing depends on availability of funds and launch vehicles as well as launching facilities.

Need for Research

Asked whether NASA will engage in development work in areas where private industry plans to carry on developments for commercial operations, Glennan said that considerable research and development must be accomplished before an operational communications system can be brought into being and that it is too early to assess the respective contributions of private enterprise and NASA in this field.

NASA's program, Glennan said, "should stimulate those developments which promise early economic benefits to our citizens," and he said that cooperative efforts between government and industry, in space activities, should be encouraged whenever possible.

Possible Duplication

In reply to the question of possible duplication or overlap between NASA and Defense Department communication satellite programs, Glennan said that the technical requirements for military and communication satellites differ in many respects. The Unmanned Satellite Panel of the Aeronautics and Astronautics Coordinating Board "is directly engaged in facilitating the coordination of NASA-Defense work on communication satellites," Glennan noted.

The issue of potentially duplicative activities will be resolved by discussions and agreements between the two agencies initiated through this board.

Johnson's letter to Glennan followed the NASA administrator's Oct. 12 speech in which he outlined the agency's future communication satellite policies. This included an offer of joint NASA-industry programs in which NASA would provide launching facilities at cost. In reply to Johnson's question whether this proposal to provide launch vehicles, facilities and services on a cost-reimbursable basis represented official executive branch policy, Glennan said that it did but that "any final action . . . will most certainly have specific approval before funds or other legislative actions are requested." Glennan said that NASA's existing statutory authority "appears sufficiently broad" to cover such a program.

Prior to Glennan's Oct. 12 statement, there had been concern among officials of AT&T and other commercial communications firms that the government might use the communications satellite as a wedge for entering the commercial communications field. Glennan's statement therefore was warmly received.

Sovereignty Called Space Law Key

Washington—Basic legal problems in space are concerned with establishing the upper limit of territorial sovereignty but the time has not arrived for developing international space law in this or other areas, according to the American Bar Foundation.

The bar foundation report and recent legal discussion indicate a trend away from limitless sovereignty claims by nations and toward agreement that sovereignty ends at an altitude somewhere below the lower orbiting environmental limit—about 90 mi. above the earth.

The research effort by the bar foundation is a comprehensive analysis of existing international literature on space law. It is the second in a series of social and economics studies being funded by the National Aeronautics and Space Administration through its committee on long-range studies (AW Nov. 21, p. 28).

The foundation reaches few conclusions in the work, but the most significant is the warning that experience in space is too meager to attempt to arrive at an international space law. In addition to an agreed definition of sovereignty, such a comprehensive agreement will hinge on these basic problems:

- **Defining peaceful** vs. military use of space.
- **Radio spectrum management** and radio and television relay satellites.
- **Conservation of space.**
- **Weather forecasting** and control.
- **Safety standards** and damage claims.
- **Repossession** of projectiles and repatriation of personnel.
- **Observation satellites.**
- **International coordination.**

Legal Observations

The report appraises current legal observations of these problems, and it contains abstracts of 892 articles which form the basis for the appraisal.

The study has been in preparation since 1958 when the American Bar Assn., affiliated with the foundation, began a systematic survey of literature as a first step toward developing recommendations for a law on outer space. NASA assumed funding responsibility early last year.

Legal experts feel that any definitive progress in arriving at international agreements will be made through the United Nations General Assembly, which established legal, technical and conference committees on the peaceful uses of outer space a year ago.

NASA General Counsel John A. Johnson called the report the most comprehensive made on the general subject of space law, and he said it will be an excellent departure point for a continuing systematic study.

First Orbital Scout Launching Terminated by Ignition Failure

Wallops Island, Va.—First attempt to qualify the four-stage Scout rocket for satellite missions failed when the second stage engine failed to ignite, terminating a flight designed to launch an 87-lb. payload into an elliptical orbit.

The solid fuel research vehicle was launched Dec. 4 from this National Aeronautics and Space Administration test facility. Payload included a 14-lb., 12-ft. inflatable sphere which was to have measured air density and drag in its orbital area—410-1,275 mi.

Malfunction was traced to the ignition system. Neither second nor third stages ignited as programed during the 250 sec. before impact. Because of the high reliability of engine igniters, it is considered unlikely that the cause of failure was in the engines. It was probably in the vehicle ignition circuitry.

Launch at 80.69 deg. elevation was due east. It followed a series of countdown delays, only one of which was extensive. Hold of several hours came when the count was in the last 90 sec. It was caused by failure of a telltale light to respond to the order to uncage yaw gyros. It was necessary to discharge batteries and put the vehicle back in a vertical position before workmen could correct the fault.

Actual trajectory took the system to an altitude of 215,000 ft. and range of 80 mi. Impact came 250 sec. after launch.

Algol Motor

Aerojet-General first stage Algol motor, with 115,000-lb. thrust and total impulse of 4 million lb., performed as programed with a 44.2 sec. burning time. Burnout was visible at 70,000 ft., and a 25.6 sec. coast period was programed before second stage ignition, scheduled at 130,000 ft.

Scout second stage Thiokol Castor engine also has been used in a cluster in NASA's Little Joe program. It was programed to ignite 69.8 sec. after liftoff, separate the upper stages from the empty Algol and develop 55,000 lb. thrust during the 41 sec. burning time.

Hercules-Allegany Ballistics Laboratory third stage, 13,600-lb. thrust Antares was to ignite five seconds after Castor burnout at 315,000-ft. altitude. Antares was to have burned 39.4 sec. and to have coasted 389.4 sec. to the injection altitude of 357 naut. mi. ABL 3,000-lb. thrust Altair was to have injected the payload into orbit.

Injection was programed 10.5 min. after launch, with activation of payload inflation beginning 6 sec. later and being completed in 262 sec.

Test was the third of eight flights in the development program, which includes one more under NASA management. The remainder will be conducted by the Astronautics Division of Chance Vought Corp. Next Scout vehicle will be a probe carrying a micrometorite impact measurement payload.

Scout's Importance

NASA's first orbital attempt from Wallops Island also was the first time the agency tried to launch a satellite payload developed by its own scientists with a launch vehicle developed in-house. NASA is banking heavily on Scout for a variety of orbital, probe and re-entry applications. It also is to be used as a means of cementing relations with nations in a position to develop payloads, but unable to support the cost of booster development. NASA hopes to bring the cost of each vehicle below $1 million, compared with $3.5-5 million for launch systems based on Atlas, Thor and Jupiter vehicles.

The same NASA team that developed the 100-ft. Echo I satellite also prepared the 12-ft. sphere payload for Scout. The sphere, based on the Beacon payload, has not had a chance to operate in three launches. A Jupiter C launch with Beacon failed in 1958, and a Juno II launch failed last year.

Unlike Echo I, the Scout payload was a four-layer structure which would weigh 6,000 lb. if it were as big as Echo. William J. O'Sullivan, Jr., who heads the inflatable structures group at NASA's Langley Research Center, said Echo II will use stiffening techniques developed on the Scout 12-ft. sphere.

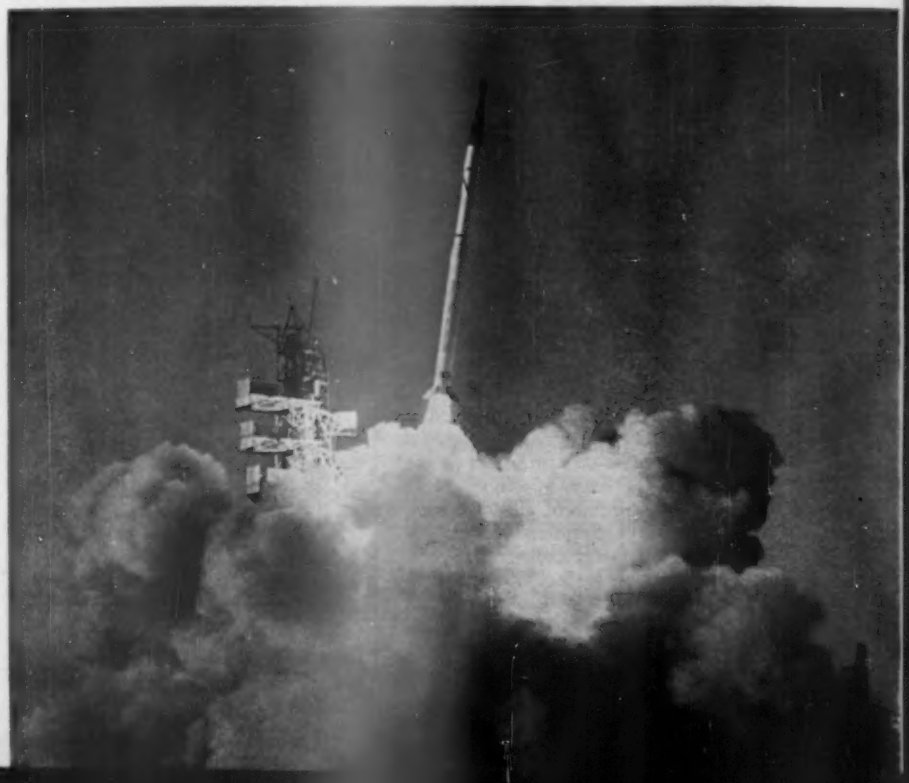
The 12-ft. sphere is made of two layers of Mylar film and two layers of aluminum foil. Echo I weighs 132 lb. and was made of Mylar with an aluminum deposit. Echo II will probably be 135 ft. in diameter, with a layer of Mylar sandwiched between two layers of aluminum.

Advanced Scout Study

Wallops Island, Va.—Studies of an advanced version of the solid fuel Scout which would give the vehicle 100 lb. greater orbital payload capability than presently are now under way. Growth from 150 lb. to 250 lb. in payload weight for a 300-mi. orbit would come from uprated third and fourth stage motors, and reduction of inert material weight in first stage propellant to allow for increased aluminum additive weight. If National Aeronautics and Space Administration, Air Force and Navy are sufficiently interested in the advanced version, it could be produced in 18 months.

Scout also may get control capability for launching satellites into equatorial orbits from Wallops. This can be done by installing a programmer to control the third stage roll jets.

FOUR-STAGE orbital Scout rocket is launched from NASA's Wallops Island, Va., facility.



Symington Plan Faces Stiff Opposition

By Ford Eastman

Washington—Proposals to streamline the Defense Department through major reorganization, recommended to President-elect John F. Kennedy last week by Sen. Stuart Symington (D.-Mo.), will run into stiff opposition both in the Pentagon and in Congress.

Army and Navy and their conservative supporters on Capitol Hill are expected to conduct a bitter battle against any moves that would tend to eliminate traditional individuality of the three services—which the Symington proposals most certainly would do. Air Force generally favors moves toward unification.

Reporting to Kennedy on the results of a study he ordered last summer (AW Sept. 19, p. 29), Sen. Symington recommended these major changes:

- **Elimination of the present** departmental structure of the three services, preserving them as separate units within a more powerful, highly centralized Defense Department. The 15 service secretaries, under secretaries and assistant secretaries would be eliminated.
- **Replacement of the Joint** Chiefs of Staff with a Joint Staff headed by a single chief who would be chairman of the Joint Staff.
- **Establishment of unified** strategic, tactical, defense and National Guard-Reserve commands, each including elements of the three services. There also would be directorates for research and engineering, production and procurement and facilities and installations.
- **Revision of Defense** Department budgetary procedures.

Sen. Symington said further study will be needed to determine how much of the reorganization could be accomplished by presidential directive based on existing legislation and what new legislation would be required.

Major Opposition

The Symington plan is similar to measures previously introduced in Congress which have been opposed in many military quarters as well as by some members of the House and Senate (AW Aug. 15, p. 29). The major part of the opposition is expected to be directed at elimination of the service secretaries and departmental structure, and of the Joint Chiefs of Staff, and revision of the budgetary procedure, although each has come in for considerable criticism from Congress in the past.

Initial reaction to the Symington report was cautious, and official statements from military leaders and members of Congress were sparse. Kennedy's only comment when he received the report was that it was an "interesting and constructive" proposal and that he was sure it would be carefully analyzed by Congress and his new administration.

The radical Symington proposals undoubtedly were made public at this point as a trial balloon to determine public reaction to a drastic reorganization of the Defense Department before specific recommendations were transmitted to the new Congress. The proposals probably will be moderated somewhat in an effort to reduce opposition and secure at least a partial reorganization.

Eisenhower Administration defense officials generally maintain that the reorganization launched in 1958 should be given a chance to work before further changes are made. Army Chief of Staff George H. Decker echoed this philosophy last week in Alaska when he said he feels "the department is still on its shakedown cruise."

Air Force generally favors changes such as those recommended by Symington. USAF studies indicate these moves would promote economy, efficiency and unity of effort, but detailed comment on the plant will await further study.

Navy's Views

Navy completed a working paper last September which essentially opposed any drastic changes of the type suggested last week and agreed with Defense Secretary Thomas S. Gates in his plea for further trial of the 1958 reorganization. Navy expects civilian opinion to have the determining effect in the coming battle, largely because service opinion is already established while opinion outside the services remains to be tested. Air Force and Navy already are at work presenting their views on reorganization to influential civilians.

Making his report public, Sen. Symington said in any appraisal of the U.S. military posture, one "salient" factor stands out above the rest—the threefold significance of reaction time at this stage in history. First is the unprecedented strategic value of time—the ability to react instantly against aggression in this nuclear-space age; second is the crucial time element in the U.S. vs. Soviet arms race—the need for early selection among alternative weapon systems and for shorter lead times between conception and use; third is the effect of time on defense cost.

Sen. Symington said the central theme of clarification and strengthening of the authority of the Secretary of Defense over the entire U.S. military establishment has run through all past and current proposals to make the Defense organization more effective.

Military services would be retained under the Symington plan, but the present departmental structure of the Air Force, Army and Navy would be eliminated. This would do away with the present service secretaries, under secretaries and assistant secretaries. The services would remain separate organic units within a single department, headed by a chief of staff and subject to the direction, authority and control of the Defense Secretary.

New Civilian Offices

Two new under secretaries of defense would be created, one for weapon systems and one for administration. These two, along with the Defense Secretary and Deputy Secretary, would comprise the statutory appointees in the department. In addition, the Defense Secretary could designate such civilian assistants as he considers necessary. The seven existing assistant secretaries of defense would be eliminated and their functions would be absorbed by directorates set up under the two new under secretaries. Directorates would be subject to change by the Defense Secretary and should not be frozen into a pattern fixed by legislation, the committee said.

The under secretary for administration would be responsible for such activities as financial management (comptroller), personnel, legal, transportation and communications, legislative, congressional liaison, public information, and health and medical. Thus, all military personnel would be subject to similar recruitment practices, rules for training and length of service, pay for comparable responsibilities, and flexibility of assignment and transfer within and among the services and service

Saturn Glider Proposal

Washington—Proposals for recovery of Saturn boosters by use of Rogallo-type cloth wings have been made to the National Aeronautics and Space Administration by Ryan Aeronautical Corp. and North American Aviation.

Rogallo wings, named for the head of the group which experimented with them at NASA's Langley Research Center, can be carried in containers and deployed at supersonic speeds. The wing form permits glide at 25 to 50 kt. forward speed. This is one of several recovery concepts being studied by NASA (see p. 82).

Glider proposals call for boosters to land in the Grand Bahamas or return to Cape Canaveral after burnout.

schools and academics. There would be unified direction and responsibility for all service schools and other military educational institutions.

The under secretary for weapon systems would be responsible to the defense secretary for the complete cycle of weapons development, procurement and production and for construction and installations, including bases, housing and depots. These activities would be managed through three directorates: Research and Engineering, Procurement and Production, and Facilities. The R&E Directorate would take over the functions now carried on by the present Director of Defense Research and Engineering and in addition would be responsible for these activities now in the office of the defense secretary: the Science Advisory Board which was formerly the Strategic Missiles Evaluation Committee; Research and Development Policy Council; Defense Science Board, and the Ballistic Missile Committee. Functions of the Advanced Research Projects Agency would be absorbed in this directorate.

Procurement and Production

All Defense procurement and production functions would be the responsibility of the Procurement and Production Directorate. The Directorate of Facilities would be responsible for the planning and construction of facilities for research and testing of weapons, industrial-type facilities for weapons production and maintenance, facilities for weapons operation—such as missile and space vehicle launching installations—and non-combatant facilities, such as on- and off-base housing.

There would be a special assistant to the defense secretary for arms control who would serve as the Defense liaison in that area with the State Department or other agencies.

The Joint Chiefs of Staff would be reconstituted so the chairman of the Joint Chiefs would become chairman of the Joint Staff. He would be the principal military adviser to the President and defense secretary. The chairman of the joint staff would enlarge the staff "commensurate with the added responsibilities of the chairman." The present authorized strength of the staff is 400 officers, plus civilian employes and enlisted personnel.

Instead of presiding over the Joint Chiefs of Staff, the chairman would preside over a group of senior officers from all services known as the Military Advisory Council. Each of the senior officers would be appointed to the council by the President and would no longer have any functions or responsibilities in the service from which he came.

These officers would never return to their services.

Rolls Seeks Government Financial Aid

London—Rolls-Royce, Ltd., has told the British government it urgently needs substantial financial aid in development of civil aircraft turbine engines in its "battle for survival," but response to the plea has been cool.

The request by Rolls' chief executive J. D. Pearson centered on the company's turbofan family and on future requirements for supersonic transport powerplants. There also are overtones of concern about Bristol Siddeley's increasing impact in the turbofan field with its BS 53 and BS 75 (see p. 119).

Minister of Aviation Peter Thorneycroft said that negotiations are under way with Rolls, but mentioned only the company's RB.163 Spey turbofan, powerplant for the de Havilland DH-121 Trident jet transport.

Engines involved in Rolls' request for government help also may include the RB.162 turbine for VTOL airframes.

The minister at the same time pointed out that the British government has contributed $800 million to the industry for aeronautical engine research and development over the past decade, and has recovered only $48 million.

Pearson said cost of developing an engine now is as expensive as development of the airframe for which it is intended. "Clearly such an investment is unlikely to be recovered from a single aircraft project," Pearson added, "and it emphasizes the importance of harmonizing civil and military requirements."

Rolls believes the government should give engine manufacturers an indication of powerplant requirements for the projected supersonic transport for which British Aircraft Corp. has been awarded initial contracts.

Pearson stressed that risks and financing required for continued exploitation of Rolls' position in the engine manufacturing field were beyond the company's capacity, and he called for the same kind of help its major competitor, Pratt & Whitney, received from the U. S. He pointed out that Rolls has supplied gas turbines for more than 1,000 civil aircraft out of a world total of 1,760 planes using this type of power.

Pearson's position could be considered a plea for preferential government treatment in its industrial aid program, at least as far as engine development is concerned.

He noted that successive ministers had declared the government's aims to be the reinforcement of the industry at its points of strength and that largely meant helping those companies which had shown ability to succeed in world markets, an obvious reference to Rolls' international activities.

Each of the services would have a Chief of Staff who would not serve on the Joint Staff or the Military Advisory Council, but who would report directly to the defense secretary.

There would be three unified commands and the commanders would report directly to the chairman of the Joint Staff. These Commands are Strategic, responsible for all strategic missions; Tactical, responsible for all limited and conventional war missions, and Defense, responsible for all continental U. S. missions.

Other Commands

Each of the unified commands would include all personnel, equipment and weapon systems required for the performance of its respective missions. To the extent that any regional or area specified commands would be required in addition to the unified commands, their commanders would also report directly to the chairman of the Joint Staff, and these specified commands would be composed of units assigned from the unified commands.

There also would be a unified command in charge of the National Guard and Reserve elements of all the services. In addition to its other functions, this command would be responsible for civil defense and would report directly to the chairman of the Joint Staff.

The defense secretary would be required to present to the appropriate committees of Congress a detailed explanation of the military requirements for all missions and Defense Department operations prior to the presentation of the defense budget to Congress. At the present time, the services usually give a detailed explanation of their programs and requirements to the congressional appropriations committees following submission of the budget to Congress, although the Armed Services Committees have held "posture" hearings earlier. However, Congress already had ordered in 1959 that, starting this next session, funds requested for procurement must be authorized by Congress first before the appropriations can be made.

Appropriation Shift

The appropriation of all defense funds would be made to the defense secretary. Presently, they are made to the services by title. Certain categories of the defense budget, such as research and development and long-lead time procurement, would be put on a multi-year instead of a one-year justification and appropriation cycle.

NATO Dispersal Plan Keynotes Nuclear Stockpile, Logistics Need

By Cecil Brownlow

Paris—Need for a more flexible policy to mate nuclear warheads with their delivery systems will become more acute during the next few years as the North Atlantic Treaty Organization disperses its forces more and more in an effort to minimize the losses it would sustain in any initial attack.

Aside from the political and psychological implications involved, this fact doubtlessly was one of the major reasons behind the proposal of Gen. Lauris Norstad, supreme allied commander in Europe, that NATO be made the world's fourth nuclear power (AW Dec. 5, p. 29).

Under the present stockpiling program largely dictated by U.S. law, which demands that American nuclear weapons remain under U.S. control at all times, most atomic warheads are held in central storage areas spotted in European NATO nations—except France, where they have been banned by French President Charles de Gaulle, and in Norway and Denmark where the presence of foreign troops is prohibited.

In times of crisis, according to one NATO official, "we would put them where they are closer to the weapons," presumably on the sites themselves. The central stockpile concept also is backed by an elaborate logistic plan designed to get the warheads to their delivery systems as fast as possible if the need should arise and there is no advance warning.

Most Western officials, however, seem to feel that at least some advance intelligence warning will be available. One said last week: "If he [Khrushchev] shifts his power, we get word of it and shift accordingly."

Fourth Force Upheld

The plan for a fourth atomic force, another said, "would help our problem quite a bit," particularly as NATO's capability for mobility improves, "but, if we don't get it, we can live with the present system."

Increased mobility—"and our direction will be very heavily in this direction during the next few years—" probably will include Polaris solid-propellant intermediate range ballistic missiles stationed aboard railway flat cars and on barges with as little reliance as possible on fixed bases.

On the European continent itself—independent of backup Strategic Air Command and British Bomber Command strategic forces—NATO already has "a pretty substantial strike capability," according to officials here.

Aside from U.S. forces in the area, which provide by far the greatest punch, other nations which have or will soon receive a tactical atomic strike capability include Germany, Italy, Belgium, Holland, Greece and Turkey. Plans also provide for rushing nuclear warheads into France and the two Scandinavian NATO members in any emergency where the danger of war is considered imminent. In any war, one official says, "France would have a nuclear capability."

French Atomic Force

French government's plan to develop an atomic strike force won its third approval by the National Assembly and thus becomes law despite the bill's double defeat in the French senate.

Political and technical battle over the program, which covers the five-year period from January, 1960, to January, 1965, has created doubts about the future of the force concept (AW Oct. 31, p. 34).

Most political observers, for example, agree Assembly approval would have been withheld except that many deputies, who argued against the government's desire to develop an independent nuclear deterrent, nonetheless backed the bill in order to avoid a political crisis in light of the Algerian problem.

Earlier, French Defense Minister Pierre Messmer told the Western European Assembly meeting here that France's insistence upon developing an independent nuclear capability does not mean that she will block efforts to find an "arrangement" with other NATO nations as to its control.

NATO Strike Force

French delegates to the Assembly also approved a resolution recommending the organization of a NATO striking force under the equal control of the 15 member nations. Of the seven countries represented at the conference—France, Great Britain, West Germany, Italy, Belgium, The Netherlands and Luxembourg—all but the United Kingdom delegation supported the recommendation.

Gen. Norstad told the Assembly that a mobile NATO strike force is now being equipped with nuclear, as well as conventional, weapons. Plans for the force, originally drafted last spring, call for it to reach a total of approximately 4,000 men drawn from a number of NATO nations. Under present conditions, nuclear warheads must remain under U.S. control.

Gen. Norstad's proposal to make NATO the fourth nuclear power is expected to be discussed in some detail at the annual ministerial meeting which convenes here late this week. However, a final decision as to whether to adopt the program is not expected before the annual defense ministers meeting in March.

Douglas Cuts Work Force by 2,300

Long Beach, Calif.—Cutback in Douglas DC-8 jet transport production from eight to four aircraft per month, coupled with the phase-out of C-133B production because of a lack of new or follow-on orders, has caused Douglas Aircraft Co. to cut its work force here by more than 2,300 workers. Layoff of 700 persons last Friday, in addition to the layoff of 1,609 employes the preceding Friday, leaves a total work force of approximately 12,100 at the company's plant here.

Last week's layoff included 550 clerical workers and 150 production line workers. Most of those previously laid off were production workers.

Production of the C-133B will be phased-out about Mar. 1, 1961, if no follow-on orders are forthcoming. DC-8 production schedule was changed Dec. 1 to the rate of four per month since no new orders had been received for the jet transport. With present scheduling on existing DC-8 orders, the production program will continue into 1962. Promised delivery dates will be met by present production scheduling of four aircraft per month. The scheduling rate change from eight to four per month was laid down by Douglas management more than a year ago.

Douglas will not comment, but AVIATION WEEK has learned that the present four per month rate probably will drop to three and possibly two aircraft per month in the late spring of 1961.

As of last Friday, Douglas will have dropped 5,600 from the Long Beach payroll since last Sept. 4, when employment totaled 17,700. Peak postwar employment figure for Long Beach was 23,300 in August, 1959.

Possibility of immediate work in the Long Beach plant through an order for a swing-tail turbojet cargo transport appears dim. Probability is that such a manufacturing decision will await action by the new Kennedy Administration.

Board Investigates Titan Silo Blast; Cause May Be Fuel Tank Rupture

Vandenberg AFB, Calif.—Underground explosion of a Titan SM-68 intercontinental ballistic missile during a test here may have been caused by the rupture of its propellant tanks when the launcher-elevator lowered the missile to the bottom of its silo too rapidly.

The explosion took place in the operational system test facility while contractor crews were running a prelaunch test which included fueling the missile, raising it to the surface, and lowering it back into its silo. The elevator is supposed to lower the 98-ft. missile to the bottom of the silo in exactly 90 sec. Observers and surviving data cameras on the surface told this sequence of events:

- **Elevator and missile** began to descend.
- **About 30 sec. later,** observers noted that the descent accelerated and the missile was going down too rapidly.
- **At 45 sec.,** the nose cone disappeared below the surface ahead of schedule. The last 60 or 70 ft. of descent was completed in about 15 sec.
- **At 53 sec.,** the missile exploded, spewing the elevator crib structure out of the silo, and destroying propellant and equipment terminals and everything else on the launcher side of the underground blast locks.

Investigation Board

An investigating board made up of representatives of Air Research and Development Command, Strategic Air Command, Air Materiel Command and civilian contractors in the Titan program has not reached a firm conclusion about the cause of the explosion. However, the average descent speed was about 4 fps. for the last 60 or 70 ft. and the possibility of tank rupture produced by rapid deceleration at the bottom of the silo is receiving thorough study.

The missile weighs 111 tons, of which more than 100 tons is propellant. The investigating board members recalled that an earlier Titan was destroyed at Cape Canaveral, Fla., after falling only 4 in. back to the pad when the first stage engines shut down automatically because of premature release of the hold-down clamps.

If it can be shown that impact or overly rapid braking at the bottom of the silo caused a tank rupture, the board will have to determine how the spilled kerosene and liquid oxygen were ignited. There are reported to be propellant line heaters and other hot equipments within the silo, but impact alone can cause ignition if impact is severe enough.

The board may not be able to learn why the elevator oversped because equipment was demolished by the blast. It had performed well in earlier tests with loaded missiles. Investigators could not enter the blast area during the day after the explosion because liquid oxygen continued to boil off underground and the fire hazard remained high.

The Titan was scheduled to be launched several days later from the launcher in which it exploded. The launch already had been postponed several times because of bad weather and trouble with instrumentation.

Disaster Plan

Spokesmen for Air Force Ballistic Missile Division of ARDC and Martin Co., designer of the missile, said most of the objectives for which the test facility had been designed had already been attained. No decision has been made about those not yet reached, but an Air Force officer told AVIATION WEEK that there is a longstanding disaster plan which offers several alternatives. Titan training facility TF 395A immediately adjacent to the test site may be used for some of the tests but in others the high cost of instrumenting a training facility for development tests may require other answers. No effort to reconstruct the test facility is expected.

Static firing of Titan engines in the silo launch test facility (SLTF) 1,200 ft. northwest of the silo was scheduled for this week but will be postponed until the investigating board hands in its report.

The SLTF is to be used in developing the technique of launching Titan II from within the silo.

Damage Estimate

Total damage done by the blast last week may reach $8 million, but an industry official points out that dollar estimates of damage to a development facility are always misleading. A true estimate would have to account for the per cent of development work completed in the facility and the effect of these delays imposed on program schedules.

No one was injured in the explosion because all crewmen were inside the underground control center 890 ft. away. Shock waves and fumes were kept from the control center by blast locks midway in the tunnel between the control center and the silo.

News Digest

B-70 alert pod contract has been reinstated with Beech Aircraft Corp. by North American Aviation. Pod provides all integrated prime power supply functions to start the B-70's engine simultaneously, maintain electronic equipment in "warm-up" condition and support the bomber's environmental control system. The alert pod can be carried by the bomber, but also has self-propelled mobility on the ground.

Peru has contracted to purchase 15 T-37 jet trainer aircraft from Cessna Aviation Co. Although Cessna officials declined to comment on the contract, it was learned that the contract has been signed and an export license obtained for the aircraft.

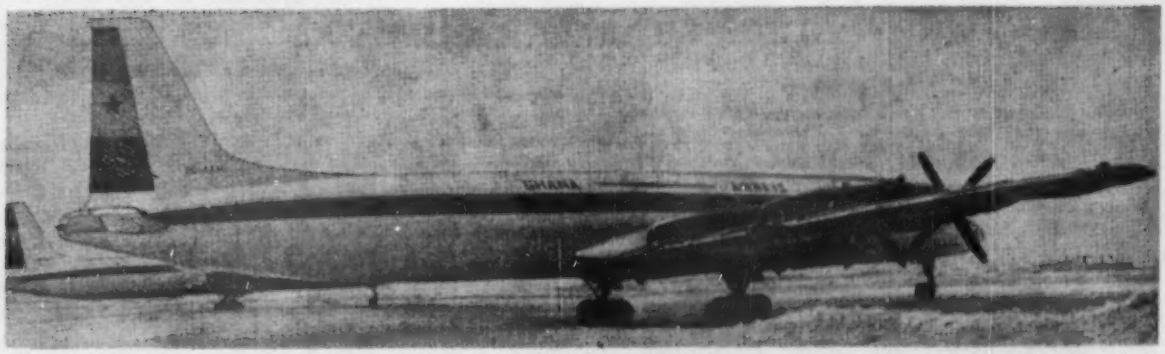
T. Roland Berner, who ousted Roy Hurley from Curtiss-Wright Corp. last spring, was elected president of the company last week. Berner originally had taken over the chairmanship while the search for a new chief executive was on, but was asked by the board to take over the job himself on the basis of his work in reorganizing the company.

Directors of North American Aviation, Inc., have named J. L. Atwood, president, as chief executive officer of the company. J. H. Kindelberger, chairman of the board since 1958, will remain chairman of the board and executive committee.

Polaris A2 test vehicle flew 1,600 mi. downrange from Cape Canaveral last week.

Navy task force composed of the carrier Wasp and four destroyers was withdrawn last week from a patrol of the Caribbean area designed to protect Guatamala and Nicaragua from possible invasion. It was stated that White House said the countries involved had declared the emergency ended.

New antenna arrays will be installed at all Minitrack stations by next June to convert tracking frequencies to 136-137 mc. from the crowded 108 mc. spectrum. Six stations already have 136 mc. tracking ability. Shift is being made at the request of the Federal Communications Commission.



FIRST TWO Ilyushin Il-18 turboprop transports for Ghana Airways were exhibited at Moscow's Sheremetyevo Airport with the airline's markings before their flight to Accra. Russia expects to turn over another pair of Il-18s to the African carrier "in the near future." Russian crews making the ferry trips to Accra will remain in Africa to train Ghana Airways personnel in Il-18 operations.

Ghana Builds Flag Carrier for 'Prestige'

Ghana Airways plans mixture of Soviet, Western transports, admits that line will not show profit.

By Robert E. Farrell

Accra, Ghana—State-owned Ghana Airways plans to use Soviet and Western turboprop and jet aircraft in a costly and somewhat confused expansion program designed to convert the airline from a regional to an international operator.

Formed two years ago, when Ghana proclaimed its independence within the British Commonwealth, the west African carrier now is being wielded as a "prestige instrument" by the nationalistic-minded government of President Kwame Nkrumah. Ghanaian officials flatly admit that Ghana Airways "is not a commercial operation and isn't trying to be one." Moreover, they boast that substantial losses are going to be underwritten in order to make Ghana Airways the dominant carrier of independent Africa.

To achieve this stature, the Ghanaian government already has launched into an equipment-buying spree and is beginning to plan a staggering network of routes aimed at linking Accra with major capitals on both sides of the Iron Curtain. One Western aviation observer here describes the government's aviation policy as "first buy new equipment, then see where you can fly it to."

Main topic of aviation conversation here is the government's purchase of six Russian Il-18 turboprops, all of which are slated for delivery by year-end. Although no official figures have been released on Il-18 purchase or operating costs, reliable aviation observers in Accra gave AVIATION WEEK the following information:

Purchase price for each aircraft amounted to $1,820,000, payable within eight years at an interest rate of 2.5%. Purchase price includes use of one full crew for nine months, with Ghanaian government paying for the use of Russian air crews after the initial nine-month period. For the six aircraft about 90 Soviet air and ground personnel will be needed. Aircraft, at least initially, will be maintained in Moscow.

A limited amount of air crew training for selected Ghanaian candidates will be provided in the Soviet Union. This training, however, is to be paid for separately by Ghana.

"Widely uneconomic" is the phrase one informed aviation source used in describing operating costs of the Il-18s. Getting hold of such figures, however, is extremely difficult in Accra. No official is willing to be quoted publicly on the Ilyushin operation. AVIATION WEEK was told that the heavy cost item centers on the Il-18s' four Ivchenko 4,000-shp. turboprop engines.

According to those sources, Russians are recommending major engine overhauls after 500 hr. and complete scrapping of the engine after 2,000 hr. Cost of the engine reportedly is $92,400. Since Ghana Airways is hoping to get about 2,000 hr. utilization annually out of each Il-18, this theoretically could mean an annual engine replacement cost of over $2 million for the entire six aircraft.

No source was aware of any deal under which the Russians allowed a "trade-in" cash value on scrapped engines.

Ghanaian officials, when confronted with these Il-18 cost figures, refuse to comment on them. They merely fall back on stated government policy that Ghana Airways "is not a commercial operation." This attitude is reflected in the government's attitude toward the carrier's annual operating deficit. This figure, roughly $200,000 shortly after the operation got under way in 1958, has been declining steadily year-by-year. But now that the government has decided to "go international," carrier officials are projecting an annual operating deficit of over $3 million for 1961.

Reported heavy operating costs of the Il-18s aren't the only reason the carrier is projecting heavy operating deficits. Another contributing factor is the simple fact that Ghana Airways is changing rapidly from a regional carrier into an international operator. Equipment, moreover, is being bought even before new routes have been laid out.

Until recently, Ghana Airways was running a fairly modest operation involving four Douglas DC-3s and two de Havilland Herons. The DC-3 aircraft are flown on a west African coastal route under a pool arrangement with Nigerian Airways. Herons are used mainly within Ghana. Also, twice weekly Ghana Airways charters BOAC equipment – Britannia 102s – between Accra and London. These twice-weekly flights were operated by BOAC crews while the aircraft carried Ghana Air-

ways markings. This modest equipment and route setup is now undergoing sweeping changes along these lines:

- **Two Bristol Britannia** 300 series, delivered in November.
- **Six Ilyushin Il-18 turboprop** aircraft, all to be delivered by year-end.
- **Three Vickers' Viscount** 800 series, to be delivered in mid-1961.
- **Two or three U. S.** and/or British jets. Ghanaian officials say they are interested in Boeing's 707 and Vickers VC-10. Talks with both companies are under way (see p. 50).

Ghana government wants to buy Boeing 707-420 turbojets despite Boeing's advice that the 720B intermediate range model is best suited to the needs of the flag carrier. Ghana officials admit they are attracted to the 707-420's size, even though the Accra runway won't permit maximum takeoff weights for this airplane. Boeing also is discussing a limited amount of pilot training, if Ghana Airways orders its transports.

All of this equipment was ordered and paid for by the Ghanaian government, not by the airline. On some equipment, notably the Il-18s, the carrier wasn't even consulted. Negotiations are carried out by the Minister of Transport and Communications, leftist-leaning Krobo Edusei, who also wields considerable influence in Ghanaian politics. Edusei's aviation policy seems to be aimed at equipping Ghana Airways with the "biggest and best" Soviet and Western aircraft, and then operating such aircraft into as many world capitals as possible.

Despite Ghana Airways' new equipment program, carrier officials are still extremely vague as to where the new aircraft are going to be operated. Moreover, the operations and maintenance problems of the carrier are of a unique nature. BOAC officials, who run the airline under a management contract, maintain a pained silence when questioned on how the carrier plans to operate a fleet of aircraft flown by British and Russian pilots and maintained in London and Moscow.

On route structure, the only certainty is that the carrier's newly delivered Britannias will take over on the Accra-London twice-weekly run from the chartered BOAC operation. One route runs from Accra to London via Barcelona. Second route goes from Accra to London via Tripoli and Rome. Carrier does not have Fifth Freedom rights en route.

Ghana Airways will operate this Accra-London service under a pool arrangement with BOAC. Carrier hopes to be able to offer nonstop Accra-London service next spring when a new runway at Accra will permit maximum takeoff weights for the Britannia.

Ghana Airways expects to be operating its fleet of Il-18s by year-end. For the moment it is expected they will be put on the west African coastal route, replacing the DC-3s. This route, operated in a pool agreement with Nigerian Airways, links Accra on the north with Dakar, Bathurst, Conakry, Freetown, Robertsfield (Monrovia) and Abidjan and with Lagos, Nigeria, to the south. Il-18s will operate this route at least until the carrier takes delivery of its three Viscount 800s in mid-1961.

Outside of this established route structure, the only new route in the offing is one linking Accra to Beirut via Kano, Nigeria; Khartoum, Sudan; and perhaps Cairo.

This route is slated to be opened next spring with Britannia and perhaps Il-18 service.

The carrier, however, has been told by the government to prepare studies on new routes from Accra toward such distant points as Moscow, New Delhi, Tokyo, Rio de Janeiro and even New York. It is with such routes in mind that Ghana is negotiating for long range Boeing 707s and Vickers VC-10s.

While the government is determined to build up Ghana Airways as an international carrier it is also seeking to put Accra Airport on a par with other west African airports such as Dakar in the Senegal and Kano in Nigeria. To do this, the government has granted Fifth Freedom rights virtually to any carrier willing to fly into Accra. At the moment 12 carriers are now offering service to Accra.

Government also is about to grant full Fifth Freedom rights to El Al Israel, United Arab Airlines and Ceskoslovenske Aerolinie, the Czech National airline. CSA currently terminates its Prague-west African service in Conakry, Guinea.

This generous aviation policy already is hurting Ghana Airways. Carrier's biggest revenue gainer was its pool deal with BOAC on the Accra-London service. Yet the Ghanaian government waved aside carrier protests in granting KLM full rights on the Dutch carrier's new weekly service between Amsterdam and Accra via Zurich and Tunis.

Moreover, the Ghanaian "oper-door" aviation policy is beginning to annoy its big neighbor, newly-independent Nigeria. Latter country currently is following a much more conservative aviation policy in an attempt to build up a national carrier. Nigerian government reportedly feels that Ghana's ambitious plans are confusing the whole aviation picture in west Africa.

Western observers in Accra also wonder whether the Ghanaian government fully understands the heavy financial load involved in its undertaking in beefing up Ghana Airways. Ghana admittedly is a fairly rich country by west African standards. But the government is spending huge sums in fields other than aviation, and observers wonder how long the government can underwrite Ghana Airways' slated annual operating deficit.

Moreover, the present aviation situation in Ghana presents BOAC with a delicate problem. BOAC signed a seven-year management and training contract with the Ghanaian government when Ghana Airways was set up in 1958. Contract was signed, however, before BOAC was aware of the Ghanaian government's airline ambitions or its intention to operate Russian aircraft.

Now, BOAC management personnel working for Ghana Airways find themselves committed to run an airline whose important equipment and route decisions are often made without their knowledge. And if the whole costly operation collapses someday, it is only natural to expect the Ghanaian government to put the blame on the BOAC management.

For the moment, BOAC seems resigned to follow a tight-lipped policy. Moreover, if it decided to move out of its management commitment it is probable that the Russians would immediately offer to move in. This transfer would be fairly easy to make since Russian aircraft and personnel already are being phased into Ghana Airways.

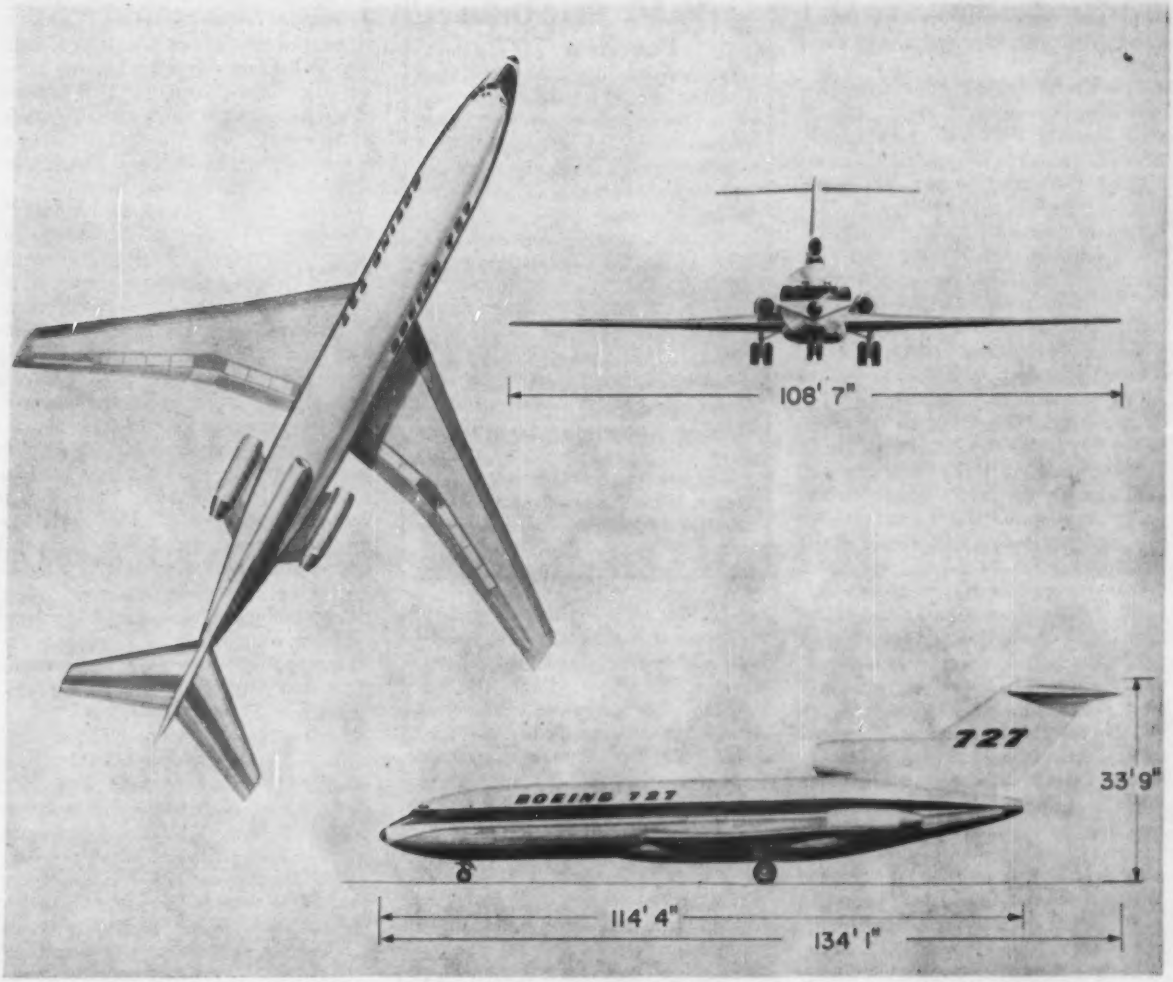
Ghanaian government's new equipment purchases, moreover, emphasize the airline's non-African character. Until recently only some 30 employes—mostly top management and pilots—were non-African out of a total of some 350 employes. Now with nearly a hundred Russian air and ground crewmembers moving in, plus British crews for the Britannias and Viscounts, the airline is losing what little African coloring it had.

PanAm Near Order For New 707

Pan American World Airways is close to signing an order for five and an option for five more turbofan-powered Boeing Intercontinental 707 jet transports fitted with full span leading edge flaps and modifications to contour and slots of the training edge flaps.

The airplane, designated the 707 - 321B, is not the same as the Boeing 707-520B which Pan American was considering (AW Nov. 14, p. 52), and will be powered by the current version of the Pratt & Whitney JT3D-3 rather than the advanced JT3D-5 in the 707-520B. A foreign airline also is reported interested in a Conway-powered version of this airplane.

Pan American probably will use the airplane in the Pacific, where it could fly New York-Honolulu nonstop consistently.



BOEING 727 wingspan will be 108 ft. 7 in., over-all length 134 ft. 1 in., height from ground 33 ft. 9 in. and fuselage width 12 ft. 4 in. Wing sweepback at the quarter chord will be 32 deg. Maximum gross weight will be 142,000 lb.; plane will cruise at 550-600 mph.

Eastern, United Order Boeing 727 Jets

By Glenn Garrison

New York—Long-expected decision that Boeing Airplane Co. will build the short-medium range 727 jet transport was revealed last week along with confirmation that Eastern Air Lines and United Air Lines have ordered the three-turbofan powered airplanes.

Eastern will buy 40 and United has placed a firm order for 20 and an order for 20 more that will automatically become firm either with consummation of the proposed Capital Airlines-United merger, or upon the maintenance by United of certain projected financial ratios (AW Feb. 29, p. 43).

Price of the 80 planes with spares totals more than $350 million. The 727 without spares sells for about $4¼ million. Delivery is scheduled for late 1963 (AW Oct. 10, p. 42).

Boeing President William M. Allen said production drawings are now being released to Boeing shops and the first 727 is expected to fly within 15 months.

Allen called the decision to produce the rear-mounted-engine 727 "one of the most important our company has made in its existence." Boeing recognizes the substantial risks involved in the project, he said, but believes the potential is great enough to justify the risks.

Boeing must sell 200 of its 727s to make the venture a financial success, Allen said. This sales requirement is over a period of eight to 10 years.

Eastern had been looking for some time for a medium range jet that would suit the requirements of the airline's system, according to Malcolm A. MacIntyre, president of Eastern. Many of Eastern's routes are 500-1,000 mi. and many cities now served lack the traffic density to fill high-capacity aircraft, MacIntyre said. The 70-114 passenger 727 will provide the needed capacity range and also the economy to serve these points. Another factor is the short-runway requirement at many smaller cities where the aircraft must operate from 5,000 or 6,000-ft. strips.

MacIntyre said his airline will be almost completely jet-equipped with delivery of the 727s but Lockheed Electra turboprops will continue very short haul points. Average Electra segment on Eastern's routes now is 300 mi., MacIntyre said.

No firm credit arrangements have been made for the 727 purchase, MacIntyre said, but Eastern, under present arrangements, can borrow more money

when needed. No debt or equity financing for the purchase is anticipated for at least two years, and most of the funds will come from depreciation and cash flow, MacIntyre said.

United has been working for several years on its short-medium jet requirements, according to J. A. Herlihy, senior vice president-engineering and maintenance. In a worldwide search for the right airplane, United became interested in the tail-mounted engine designs "catching on" in Europe—the Sud Caravelle and the de Havilland DH-121 Trident design.

But United, which has ordered 20 Caravelles and took options on 20 more, wanted a more advanced airplane than the French twin-jet, Herlihy said. For a large-scale order and for the long-range program, United was looking for a jet "more developed in the state of the art" than the Caravelle, according to the engineering official.

The major factor in the Caravelle order was the availability of the aircraft, Herlihy said. Delivery is scheduled to begin next year. United has not yet decided whether it will exercise its option and buy additional Caravelles.

Merger Plans

The 40-plane 727 order "is only the beginning," Herlihy said. If the merger with Capital goes through, many more 727s will be needed. United will add about 20 new cities to its jet pattern with the 727, and the airplane also will serve cities already served by United's larger jets, the Douglas DC-8 and Boeing 720.

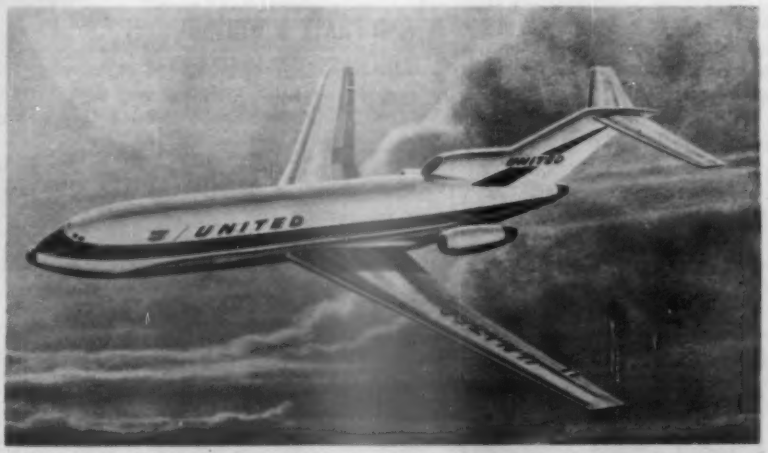
Financing for United's order will be accomplished by a program now under way, involving the sale of $25 million in convertible debentures and the expansion of a line of bank credits from $130 to $165 million (AW Nov. 28, p. 45).

Both airlines will use the 727 in mixed configuration at the start of service. But the airplane can go to all-coach at a later point, MacIntyre said, and this is one advantage it has over the Caravelle: the 727's fuselage is wide enough to permit three-abreast seating, whereas the Caravelle's is not.

The 727's high lift devices will include triple-slotted trailing edge flaps and leading edge flaps and slats. The slats extend forward and down from the upper leading edge of the wing at low speeds. In cruise, the slats retract into the wing to provide a high speed leading edge.

The aircraft's vertical fin is fitted near its top with horizontal stabilizer and elevators. Tail fin and rudder are swept sharply aft. Sweepback of the 727's wing (32 deg.) is somewhat reduced from Boeing 707 and 720 models. Control system of the 727 incorporates dual hydraulic packages to power elevator and lateral control surfaces through complete surface travel, and the rudder is controlled by dual hydraulic power packages.

EASTERN AIR LINES has ordered 40 Boeing 727 three-turbofan-powered transports for delivery in late 1963. The aircraft sells for about $4.25 million without spares.



UNITED AIR LINES has ordered 20 Boeing 727s and may order 20 more, depending on Capital-United merger, or on maintenance by United of certain projected financial ratios.

The rear-mounted engines are arranged in one pod on either side of the fuselage and a cowl-enclosed third engine suspended from a beam at the rear of the fuselage. An air intake leads to this engine from the base of the vertical fin. Gross weight of the 727 is 142,000 lb. Its Pratt & Whitney JT8D turbofan engines will produce 14,000 lb. of thrust each.

A feature of the 727 is its two sets of self-contained passenger stairs, one of which will serve an exit under the airplane's tail in the manner of the Martin 4-0-4 piston aircraft. The other integral stairs will serve the second passenger door, located forward of the wing on the left side of the plane.

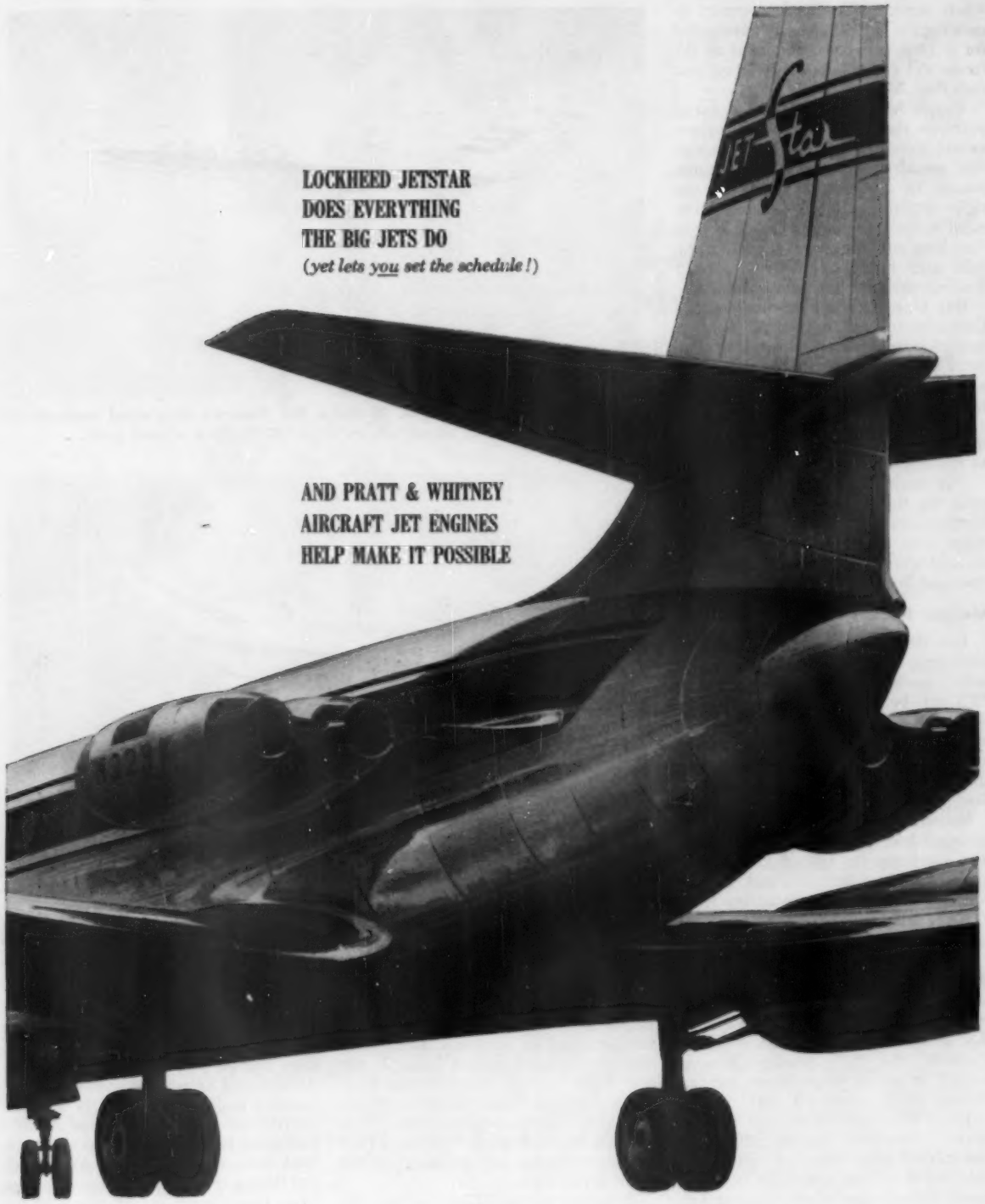
Many features of the 727 will be common to the 707 family, thus shaving some of the production costs and providing airlines with an interchangeable spare situation. A design objective was used where possible in tooling for the 707-720 series. Body width will be the same, as will principal airplane systems.

Regarding foreign markets for the 727, Allen listed Lufthansa as a strong prospect and said Boeing hopes to sell a large number of the jets to that carrier. Airlines and financial sources report the number might be as high as 25, presumably for the West German airline's European routes. Other European airlines have shown interest, Allen said, but Boeing recognizes the severe competition from foreign manufacturers of the Caravelle and DH-121. Nearest domestic competitor, according to Allen, is the Convair 880.

The three-engine configuration of the 727 is patented by Sud Aviation, and Boeing got Sud's permission to use the arrangement. The British manufacturer of the DH-121 reportedly does not have such permission as yet, although negotiations are under way with Sud.

Eastern and United worked with

LOCKHEED JETSTAR
DOES EVERYTHING
THE BIG JETS DO
(yet lets you set the schedule!)



AND PRATT & WHITNEY
AIRCRAFT JET ENGINES
HELP MAKE IT POSSIBLE

YOU say where and when—and the new Lockheed JetStar flies you there with jetliner speed, comfort, quiet and reliability. It has intercontinental capabilities, yet can land at smaller airports. Four Pratt & Whitney Aircraft JT12 engines power the JetStar. Each weighs only 436 pounds but develops 3,000 pounds thrust—one of the most efficient and reliable powerplants ever developed. Its simple, rugged design insures easy maintenance and high operational reliability. Backed by Pratt & Whitney Aircraft's world-wide service, the JT12 is an engine conceived, designed and built for business use. It's one of the reasons why so many leading firms in the U. S., Canada and Europe have already ordered Lockheed JetStars.

PRATT & WHITNEY AIRCRAFT
East Hartford, Connecticut
A DIVISION OF UNITED AIRCRAFT CORPORATION

Northeast Pilots Check Out in Convair 880

Northeast Airlines is using two Convair 880 jet transports for pilot checkout and training at Boston, Mass., prior to start of 880 service on Dec. 15; airline has ordered six 880s. Initially, Northeast will use the airplane on daily round trip flights from Boston to Miami, Fla., with one stop at Philadelphia. First 880 delivered to Northeast (above) flew from Convair's plant at San Diego, Calif., to Boston in 4 hr. 17 min. for an average ground speed of 638 mph. over the 2,730 mi. course. Second plane flew the trip in 4 hr. 19 min., reaching a peak speed of 708 mph. between Springfield and St. Louis, Mo. Sixth airplane will be delivered next February.

Boeing to standardize their aircraft as much as possible as a cost saving measure. Galley equipment, for example, will be at a similar location in both interiors-about mid-plane. In fact the aircraft for the two airlines will be similar in almost every respect, which is a departure in airline practice.

Eastern's vice president-engineering Charles Froesch, who has been interested in three-engine transports for some years, believes the primary advantage of three over two jet engines results from the turbine's loss of power on hot days. With only two engines, this loss can cut payloads to allow takeoff at required powers. Also, with two engines, Froesch told AVIATION WEEK, an airplane can be grounded by the failure of a system such as the alternator, major hydraulic pump, or cabin supercharger. With three engines, failure of one system still leaves two. Another advantage cited by the Eastern official is the three-engine plane's capability of being ferried between stations with one engine out.

Aircraft Compared

The 727 on a hot day, Froesch said, could operate from a 5,000 ft. runway where a Caravelle under similar conditions would require 7,500 ft. The 727 can operate from La Guardia Airport, Froesch said, and the Caravelle can not.

Asked about Boeing's possible plans in the supersonic transport field, Allen said his company has been spending more than $1 million a year on studies of such a project. These studies are expected to continue, he said, to keep Boeing in position to compete "when and if" a market develops for economically feasible transports in this category.

Boeing estimates the market for a 727 class airplane—in addition to 213 orders now in hand by all manufacturers—at 350 for the 1961-65 period and 575 for 1966-70 or a total of 925. Boeing expects to get its share of this market, which would be about 380 airplanes if Boeing maintains its current 41% share of the total jet transport market.

Because of the standardization of the 727, and because of what Boeing has learned in the 707 program, the company does not expect to take any inventory losses on the new airplane, H. W. Haynes, Boeing vice-president-finance, reported. One important lesson, Haynes indicated, has been in cost forecasting, and Haynes noted the 707 production cost picture has improved markedly this year.

Non-inventory charges, which include design engineering, FAA certification and other such costs not directly connected with production of the aircraft, might run as high as $4 million after taxes in 1961 and $5.3 million in 1962, Haynes said. Total non-recurring charges—which include both inventory costs such as production tooling and engineering, and non-inventory charges as certification—will total $100 million, he added.

Boeing 727 Specifications

Dimensions:	
Wingspan	108 ft. 7 in.
Length over-all	134 ft. 1 in.
Height from ground	33 ft. 9 in.
Fuselage width	12 ft. 4 in.
Wing sweepback at quarter chord	32 deg.
Maximum gross weight	142,000 lb.
Landing weight	131,000 lb.
Powerplants	Pratt & Whitney JT8D-1 turbofans (3) rated at 14,000 lb. thrust each.
Cruising speed	550 to 600 mph.
Cruising altitude	15,000 to 35,000 ft.
Operational ceiling	42,000 ft.
Range	1,700 mi.
Passenger capacity	70 to 114
Payload	24,000 lb.
Fuel	7,000 gal.
Landing gear	Tricycle: dual-wheel units
Crew	Three: pilot, copilot and flight engineer

Inherent Risks

Though Haynes pointed out the risks inherent in any such program, his forecast that there would be no inventory write-downs like those that have burdened all commercial jet transport builders (AW May 2, p. 177) indicates the initial 80 orders may put the program close to the inventory breakeven point. Haynes said this breakeven point is much lower than the 200-airplane overall breakeven.

After analysis of airline programs, Boeing is confident the airlines will be able to arrange financing for 727 orders. United's present financing program, plus its estimated cash throw from depreciation in 1964-65 of $75 million is expected to provide ample resources. Similarly, Eastern's policy of retaining earnings to build equity in previous years is regarded as significant now.

PROBLEMS? OR PROFITS?

Route pattern complexities of typical airlines demand a cargo aircraft with the capability of operating over both short and long route segments with excellent economy and earning ability. The Canadair Forty Four will do this for you! It combines the air cargo feeder liner with the long range aircraft to provide a standardized economic fleet unit. The Forty Four will give you profit-making operations, at current rates, over route segments as short as 200 miles and as long as 4,000 miles.

This is the type of flexibility that will answer the many and varied problems confronting airline operators who, because of the growing demands of shippers, are being forced to provide a combination of short, medium and long range air cargo services for the carriage of freight at attractive and competitive tariffs. In this situation, the Canadair Forty Four offers excellent economy and earning ability over the complete range of route structures that must be provided in the collection and distribution of air cargo.

Practical applications of this are found in the short route cargo services that are necessary in the supply and distribution of goods to or from the terminal points of transcontinental and trans-Atlantic services. This is evident between the major cities of the Eastern United States and between the principal points of Europe. These inter-city runs are essential extensions to the long haul trunk service, and with the Forty Four can be handled without a change of aircraft.

The need for this system of short, medium or long range operations will develop through the growing awareness among business establishments that the carriage of articles by air is becoming an essential element in the overall marketing function. This will open up new markets, new transportation requirements, new inter-city services. The Forty Four, with its flexibility of performance, can carry cargo at a profit over the whole distance spectrum—short, medium and long range, and has the airfield performance characteristics to get in and out of 85% of the world's major airports. THESE ARE DECISIVE ADVANTAGES IN FAVOR OF THE FORTY FOUR.

SOME RUNWAY AND PAYLOAD SPECIFICS ON THE FORTY FOUR-D4

1. From runways as short as 6,000 feet, can operate with 70% payload up to stage distances of 3,000 miles.
2. Can operate from 85% of the world's major airports, with due consideration to both runway length and allowable wheel loading.
3. Will earn an operating profit with load factors as low as 30%.
4. Breakeven load factors in the Forty Four represent loss loads on larger proposed equipment.
5. Breakeven load factors on larger proposed equipment represent major profit payloads on the Forty Four.
6. Can operate *non-stop* on the London-New York route with an average annual payload of over 55,000 lbs.

CANADAIR LIMITED, MONTREAL, CANADIAN SUBSIDIARY OF GENERAL DYNAMICS

FAA Eases Turbo Compound Criteria

By David H. Hoffman

Washington—Federal Aviation Agency last week offered U. S. airlines an easier way to stretch the number of hours Curtiss-Wright Turbo Compound engines may be operated between overhauls.

It did so by furnishing the industry with a new formula under which carriers can add 100 hr. to the authorized time-span separating overhauls of the 18-cylinder engines if failure rates are held below .4 per 1,000 hr. for a three-month period.

Meanwhile, Curtiss-Wright's own two-year-old program to drive down the failure rate of Turbo Compound engines has helped reduce premature removals by about 50% and promises to save the industry upward of $30 million a year in future maintenance and overhaul costs.

The new FAA "numbers" governing time between overhaul (TBO) extension for TC18 series engines represent a 100% relaxation of the old formula, which lumped Turbo Compound and turbojet powerplants together and ruled that neither could earn TBO increases until a failure rate less than .2 per 1,000 hr. had been achieved.

Working within the confines of this inflexible ratio, no U. S. airline to date has penetrated the 1,500 hr. TBO barrier on the 3,250 to 3,400 hp. powerplants used by Douglas DC-7 and Lockheed Super Constellation type transports. Foreign flag carriers, by contrast, are operating the big piston engines up to 2,200 hr. between overhauls without suffering significant increases in their failure rates.

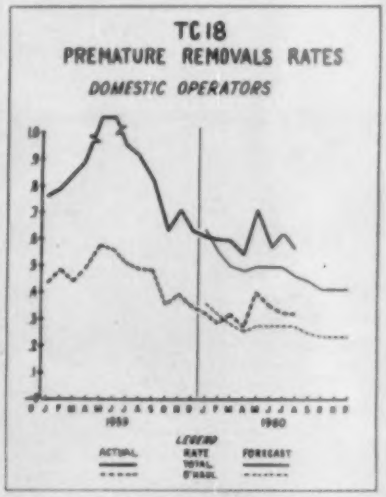
Flying some of the longest overwater routes in the entire industry, Qantas has been operating its TC18s at 2,200 hr. for months. To round out a random sampling, Trans-Canada is at the 2,100 hr. mark, while KLM and Varig use Turbo Compound TBOs of 1,700 hr. and 1,600 hr. respectively.

Operated in the United States since American Airlines inaugurated transcontinental DC-7 schedules in October, 1953, TC18 engines, through Nov. 1, have accumulated 49,799,737 hr. of military and commercial service. In all, Wright has built 3,913 commercial versions of the TC18 and more than 7,500 military models since 1952, the year production started. New engines still are manufactured for Lockheed P2V series aircraft at the Wright plant in Caldwell, N. J.

With about 2,500 sq. in. of close tolerance parts inside it (typical airline turbojets have about 100), the TC18 has not been able to match the low failure rates of most other engines in airline service. Nevertheless, the Turbo Compound powerplants have responded to the Wright reliability program in a manner best reflected by these statistics:

- **Pre-time removals** requiring overhaul numbered 3,836 in the first half of 1959. During the first six months of 1960, however, commercial operators removed only 2,466 TC18s for early overhaul—a decrease of 64%.
- **Peak premature removal** rate of 1.1 per 1,000 engine hours for any month in 1959 was reached in June by U. S. airlines. Through the summer of this year, peak rate reported was .7 per 1,000 hr. in the month of March.
- **Unmodified TC-18s**—those without the 100 deg. cam and all-steel fuel injection line fixes recommended by Wright in the summer of 1959—were removed at a .116 per 1,000 hr. rate for combustion chamber failures during the year ending Aug. 1. Engines incorporating these two fixes, by contrast, had a .031 per 1,000 hr. premature removal rate attributable to cylinder malfunctions in the same period.

Such substantial improvements in the engine's reliability indicate that many U. S. operators already are in position to exploit the new FAA TC18 Time Control Program. As a result, their TC18 TBOs probably will begin climbing before the year is out, saving each carrier roughly $2,500 per year per engine in overhaul costs as a result of each 100 hr. increase.



DARK SOLID curve shows domestic operators' over-all TC18 premature removal rate per 1,000 hr. by month since the beginning of 1959. Heavy broken line plots premature removals leading to overhaul. The two lighter curves trace industry removal rates forecast by Curtiss-Wright on the basis of data collected in its reliability program.

To avoid penalizing small operators, those with too few engines to make the failure rate formula meaningful, FAA has entrusted its field inspectors with a measure of discretion in awarding or withholding TBO extensions. Thus a carrier flying one or two DC-7s might win a new TBO increment despite a failure rate higher than .4 per 1,000 hr. if Federal Aviation Agency was satisfied after inspecting a sampling of its engines.

On the other hand, larger airlines may find their TBOs moving backward under the new formula. At rates between .4 and .6 failures per 1,000 hr., authorized TBO remains static. But FAA intends to roll TBOs backward 100 hr. if a given carrier's rate holds above .6 for a full quarter.

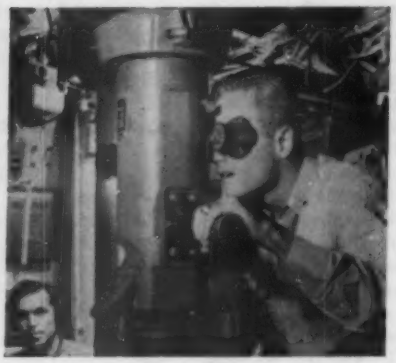
In essence, FAA's TC18 Time Control Program strikes a compromise between a rigid failure rate formula for TBO extension and a system based upon the inspection of disassembled engine in the field. The compromise lies in the "judgment factor" entrusted FAA inspectors and in the relaxation of the failure rate ratio itself.

Airlines and manufacturers, on the other hand, seem to prefer a TBO control system similar to that proposed recently by Curtiss-Wright. This would grant an operator a maximum TBO increase of 200 hr. if 85% of his engines reached authorized overhaul time without malfunctioning. To preclude excessive repair of failing engines, Curtiss-Wright urged that a maximum allowable premature removal rate of .8 per 1,000 hr. be set.

Choosing the path of compromise, FAA emphasizes that it has not abandoned its "statistical approach to quality control" in promulgating the new procedures. Now framed as amendments to each airline's operating specifications, the TC18 program will be made the subject of proposed FAA rule-making sometime next year (AW May 9, p. 38).

Hence the whole subject of failure rate formulas for controlling the TBOs of various engines—referred to as the "numbers game" within the industry—probably will be codified as a section of the Civil Air Manuals despite the heated protests of U. S. airline maintenance departments.

Keyed to a global data collection system in which every Turbo Compound premature removal is catalogued by a Wright representative, the manufacturer's reliability program summarizes the current status of all TC18 engines by month, by operator and by problem area. Sizable carriers among the 43 now operating TC18s are assigned full-time representatives. Groups of smaller



Teamwork: the best anti-submarine weapon

In the air, on the surface and under water, they work together. *Teamwork*, itself, becomes a science in hunting down a sub. Technically advanced equipment — teamed up with deadly precision — is being designed to leave enemy subs no escape. This future is taking shape now in broad studies at Vought Aeronautics. Aircraft, developed especially for most efficient use of electronic search equipment . . . advanced sonobuoys . . . even space systems, under study by Vought Astronautics. These and other ideas are undergoing analysis, or actual test in Navy ships and planes. By drawing on the broad resources of its sister divisions, Vought Aeronautics, like the Fleet, is using teamwork to serve the Navy's Number One Mission.

CHANCE VOUGHT AERONAUTICS DIVISION DALLAS, TEXAS

Riddle Completes Deal for Seven AW 650 Argosies

Riddle Airlines, Inc., and Armstrong Whitworth Aircraft, Ltd., have signed a $12 million contract for delivery of seven AW 650 Argosy four-turboprop freighters (AW Oct. 3, p. 43). Riddle subsidiary expects to receive first aircraft in San Juan this week.

carriers are served by a Wright engineer who divides his time among the maintenance bases in his area.

Trouble-Shooters

These representatives reduce all pretime removals, regardless of cause, to a punch-card report capable of being fed into an International Business Machines Corp. computer at Wright's New Jersey plant. After analysis, the cards are crosschecked for accuracy with the applicable airline's maintenance department, then run through a computer programed to furnish these three basic reports:

• **TC18 Removal and Disassembly Listing.** Published monthly, this lists all premature removals that occurred during the three months prior to the report. Information includes date, engine number, time since overhaul, geographic location of the removal, whether problem led to overhaul or repair, initial reason for removal and findings after disassembly inspection.

• **Twelve-Month Premature Removal Tabulation.** Furnished every TC18 operator monthly, this report breaks down all removals by airline, by month and by cause. Two removal values are given for each of about 55 engine areas in which trouble could develop. The first shows engines sent to overhaul and the second shows engines found repairable. Last section of the report is a summary of all operators' premature removals by cause.

• **Airlines Summary Report** of Premature Removal Analysis. Sent monthly to 20 selected operators and quarterly to all operators, this report uses curves to plot removal rates for 1960, comparing it with 1959. One curve contrasts overall removal rates; three others show removals stemming from combustion chamber, exhaust valve and impeller drive section malfunctions—the three main problem areas with the TC18.

Going beyond data analysis work, Curtiss-Wright sends a team of professional trouble-shooters to every interested airline about twice a year. After two weeks of observing the carrier's maintenance operation, during which an exhaustive questionnaire is answered, these emissaries prepare a confidential field survey report for the airline's top management.

This illuminates substandard practices and potential trouble areas, always stressing preventative rather than remedial maintenance.

En route, the Curtiss-Wright survey teams absorb any improved repair techniques originated by the carrier's engineers and pass these on to the industry. Thus the program offers a pipeline for the exchange of technical information between vendor and customer.

The industry's partial transition to jets in one sense has aided Curtiss-Wright in its effort to boost TC18 reliability. As jets replace DC-7s and Super Constellations on longer-range schedules, U. S. airlines no longer need fly their big piston transports coast-to-coast inside of eight hours to avoid double crewing. As a result, cruise power settings are being reduced, relieving some of the strain formerly imposed on TC18 engines.

Maintenance Problem

But at the same time, the jets preempted the top maintenance men in most airline shops just as the Curtiss-Wright reliability program got under way.

Their replacements, though often unversed in TC18 troubleshooting, were responsible for the Turbo Compound's falling removal rate in the last two years.

Curtiss-Wright readily admits that its reoriented TC18 reliability program was long overdue, explaining that after 30 years of close association with the airline industry, "We never quite recognized that somewhere along the line it changed from a 'small' to a 'big' business. We found ourselves with 43 operators spread all over the world, with all types of people, with all types of shops. The people dealing with us were getting farther and farther away from the hardware. Our old system of getting the facts just could not cope with the situation."

Hence the five-year lag between inauguration of TC18 service and the start of the reoriented program.

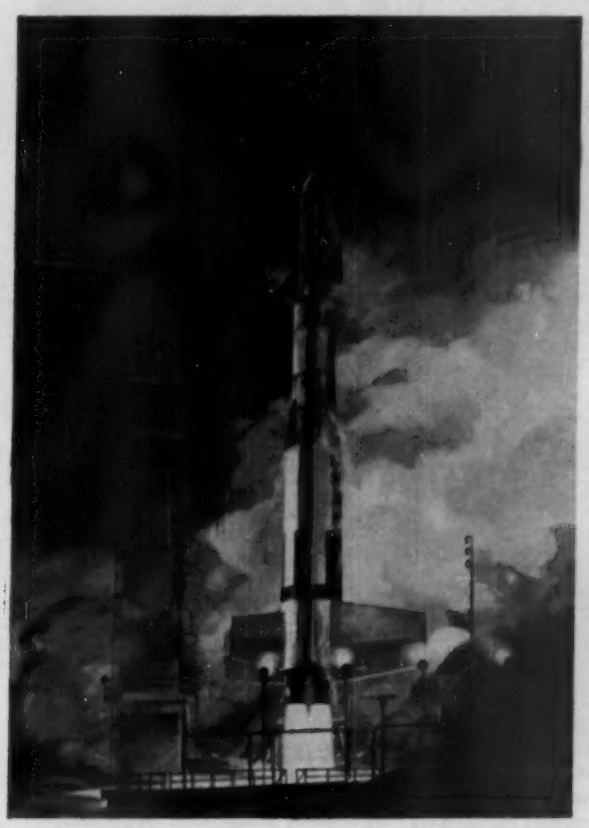
Eastern Qualifies

Miami—Eastern Air Lines reported last week that its current Turbo Compound failure rate was down to .299 per 1,000 engine hours, one of the lowest in the industry. This rate qualifies the carrier for a 100 hr. increase in authorized time between overhaul (TBO) on the big engine. Eastern, as a result, may become the first U. S. airline to achieve a higher TBO than 1,500 hr. under Federal Aviation Agency's relaxed failure rate requirement for TC18 engines. Last week, FAA doubled the number of permissible TC18 failures, ruling that .4 instead of .2 per 1,000 hr. would advance TBOs.

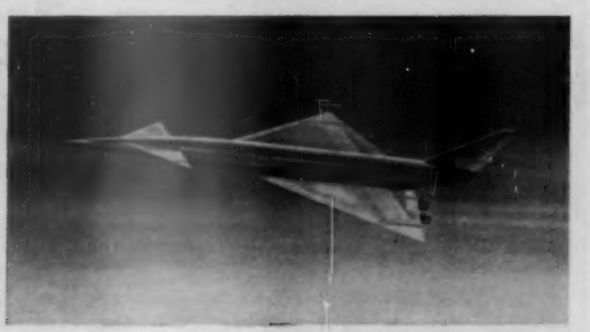
BULLETIN FROM BOEING...

...WHERE CAPABILITY HAS MANY FACES

Expanding the frontiers of knowledge through basic research is the business of the Boeing Scientific Research Laboratories, left. Here Boeing scientists are at work in the fields of solid state physics, flight sciences, advanced mathematics, plasma physics and geo-astrophysics.



SPACE GLIDER. Artist's concept shows Dyna Soar manned space glider perched atop modified Titan ICBM for launching. In space, the glider and booster would separate, leaving Dyna Soar vehicle in piloted, near-orbital flight. Pilot could later glide to conventional landing at a selected base. Dyna Soar is being developed by the U. S. Air Force in cooperation with NASA, with Boeing as prime contractor for both the system and the glider.



FUTURE SKYLINER. Boeing, builder of famous 707, America's first jet airliner, has long been at work on next generation of aerial transports, which could look like the Boeing design pictured above. Supersonic jetliners, probably a decade away, could have speed in neighborhood of 2,000 miles an hour. Flight time, from Paris to New York, would be about two and a half hours!

SHOCK TUBE. Industry's most powerful shock tube, designed and built by Boeing Scientific Research Laboratories scientists, creates shock waves which begin at 300 times speed of sound, then collide in tube at "slowed" rate of 80 times speed of sound. Gas temperature within the tube reaches approximately one million degrees. Studies could be important in developing effective ion and plasma-propulsion systems for use in space.

BOEING

JET AIRCRAFT, MISSILES, HELICOPTERS, GAS-TURBINE ENGINES, WEAPON-SYSTEM MANAGEMENT, SPACE-FLIGHT VEHICLES AND SYSTEMS.

AIRLINE OBSERVER

▶ Federal Aviation Agency is expected to complete analysis of ground and flight test data on Lockheed Electra wing modifications in January, although an intensive effort by FAA and Lockheed may make it possible to lift speed limits on modified aircraft by the end of this month. Engineering data on the modification program were approved by FAA last week. Once FAA has approved the program and issued an amended Electra certificate, speed limits will be lifted on all modified aircraft.

▶ Airline industry will launch a major campaign in 1961 to lure more travelers from the highway to air transportation. Air Traffic Conference has adopted a program which includes field survey of private automobile travel as a first step toward developing new ways of tapping this market.

▶ Russia's Aeroflot expects present dominance of turboprops in its transport fleet to continue for at least another four years. The carrier's plans call for turbojets to account for slightly over 40% of total ton miles flown in 1965. That would make the turboprop transport's share of traffic close to 55% of the total since, according to previous statements, only 5% of Aeroflot's 1965 ton miles will be flown by piston-powered aircraft. The Russian airline also reports that twin-jet Tu-104s and four-turboprop Il-18s and An-10s are now flying "over half" of total ton miles generated by Aeroflot. This compares with 10% in 1957, 17% in 1958 and 33% in 1959.

▶ Domestic trunkline earnings this year will fall about $100 million short of the level necessary to produce the 10.5% rate of return on-investment recommended by the Civil Aeronautics Board in its recent final decision in the General Passenger Fare Investigation (AW Dec. 5, p. 40).

▶ Federal Aviation Agency has proposed a major revision of civil air regulations governing U. S. flag carriers operating outside the U. S. following several years of conferences and talks with the industry and Civil Aeronautics Board. Chief purpose of the revision is to bring regulations, which were first written in 1945, up to date to conform more closely with the advancing state of air transportation and the changing characteristics of the aircraft in use. Rewriting will minimize the need for interpretative manuals issued periodically to elaborate on amendments to the regulations.

▶ Trans World Airlines' petition for a 10-day exemption to carry passengers in seven Lockheed 1049 aircraft after Jan. 1 without weather radar has been denied by the Federal Aviation Agency. Exemption was requested because of a delay in receiving Convair 880 aircraft and because of changes in corporate plans. Oscar Bakke, director of FAA's bureau of flight standards, said justification in support of the petition "is based on an internal administrative problem dealing with the purchase of Convair aircraft which is within the jurisdiction of TWA to correct" and that an exemption because of these reasons would not be in the public interest nor promote safety.

▶ Scheduled airlines have invested $49 million in the purchase and installation of noise suppressors on the 207 U. S.-built turbojet transports already delivered. Cost of one suppressor is $60,000. Douglas Aircraft Co. has estimated operating penalty of sound suppressors at $93,000 per year per airplane. When all turbojet equipment is delivered, airline industry will be spending $37 million additional in annual operating expenses to keep noise suppressed.

▶ Current NOTAMS issued by Federal Aviation Agency stress a growing trend toward flight restrictions in the Caribbean area. Cuba has established a prohibited corridor on the north coast of the island extending 30 mi. out to sea and warns that any aircraft within this zone will be intercepted by military patrols and forced to land. Haiti has prohibited non-scheduled civilian aircraft from flying over its territory and has warned that unidentified aircraft may be fired on. Dominican Republic requires that permission to land in or overfly its territory must be requested through government channels at least 72 hr. before a flight. Once permission has been received, a flight plan must be submitted 24 hr. in advance of the flight.

SHORTLINES

▶ **Air India** is planning to initiate a weekly Boeing 707 turbojet service from Bombay to Tokyo, via Bangkok and Hong Kong.

▶ **Boeing Airplane Co.** reports that as of Nov. 29, it had delivered 150 707 series and 20 720 series transports to the airlines.

▶ **British European Airways** plans to begin service with newly certificated 105-passenger Vickers Vanguard turboprops Dec. 17 for Christmas season service from London to Paris, Glasgow and Belfast (AW Dec. 5, p. 41). BEA now expects to put the Vanguard into full scheduled service in March.

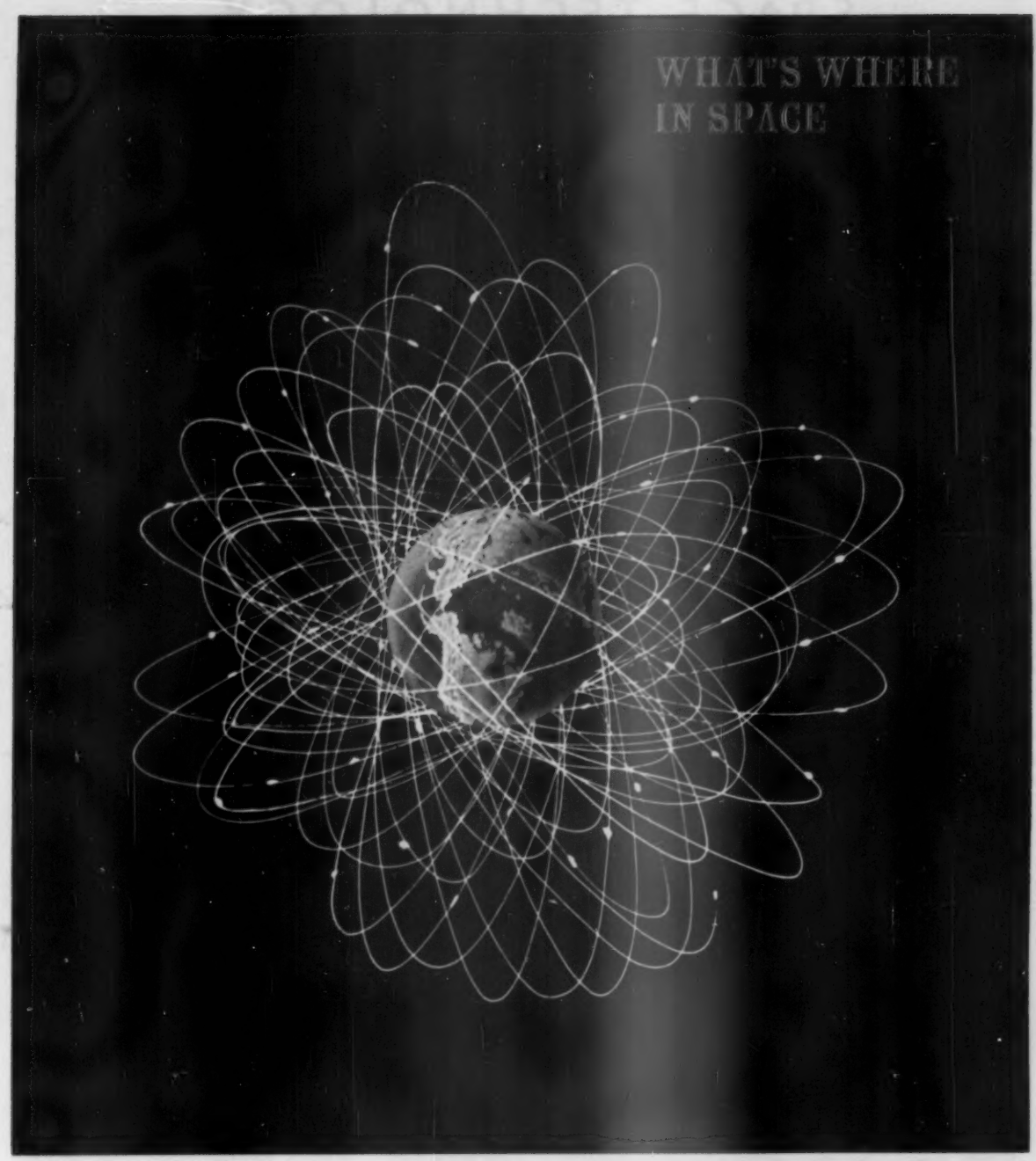
▶ **British Overseas Airways Corp.** will begin Boeing 707-436 Intercontinental nonstop turbojet service between London and Los Angeles via the polar route Mar. 2. The twice weekly flights will be operated initially with 32 seats in first class and 97 in economy class. During the peak summer season, the aircraft will carry 24 first class seats and 111 economy seats. BOAC has begun all-cargo operations with its converted Douglas DC-7F transports. The cargo aircraft can carry 30,000 lb. on flights from New York to London via Glasgow or Montreal and Manchester twice weekly.

▶ **Iberia Air Lines** of Spain has opened its new eight story administration building at 518 Fifth Ave., New York City, N. Y. Building will serve as Iberia's U. S. headquarters, with a ticket office on the ground floor.

▶ **Lufthansa German Airlines** plans to begin using the new Rhine-Ruhr Airport at Cologne-Bonn with the initiation of its 1961 summer schedules. The new international airport is scheduled for completion next spring. Lufthansa also will extend its Boeing 707 turbojet Frankfurt-Bangkok service to Tokyo via Hong Kong early next year.

▶ **North Central Airlines** has received Civil Aeronautics Board permission to overfly Manistee/Ludington, Mich., until 60 days after the cities' joint airport can make improvements enabling it to handle North Central's Convair 340 aircraft.

▶ **Sabena Belgian World Airlines** has started Brussels to Montreal and Mexico City service with twice weekly flights using Boeing 707 Intercontinentals.



phased arrays. We soon will face the crucial problem of identifying and keeping track of hundreds of man-made objects in outer space. Phased Array Radar techniques, developed at Bendix Radio, offer a solution. If many widely-spaced satellites or missiles hurtled over the horizon in the same minute, a tremendously high-powered Bendix* radar, directed by a computer, could acquire, identify, track and catalog each one without losing previously acquired targets. The Bendix Radio Phased Array Radar offers the most versatile 3-D data gathering system yet devised. It searches and tracks multiple targets simultaneously. It can provide long-range communications at the same time. If your organization deals in advanced operational concepts and weapons systems, you're invited to contact us to learn more of this latest Bendix space development.

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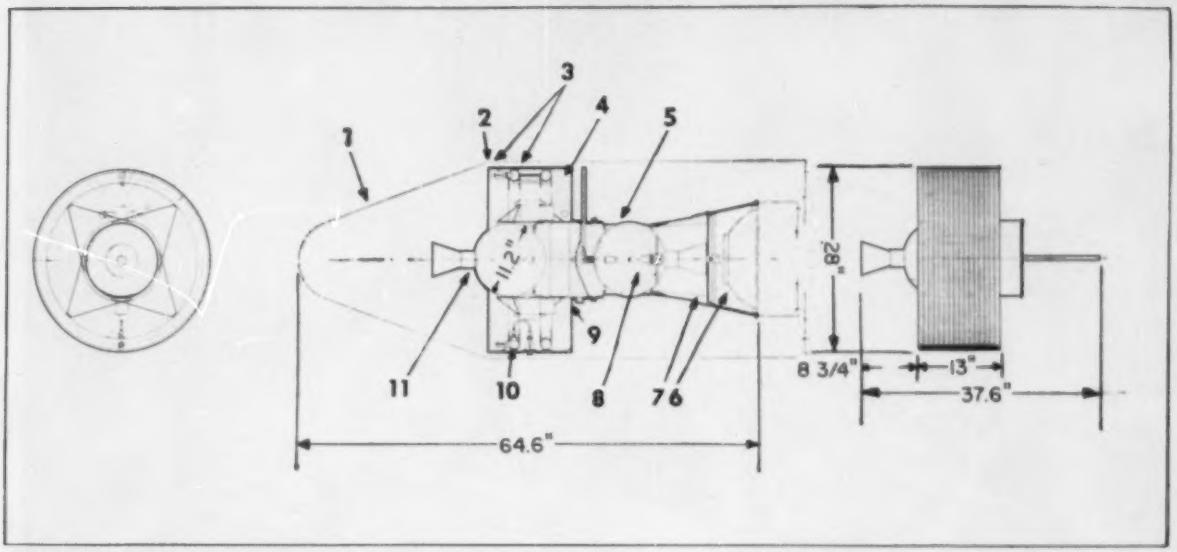
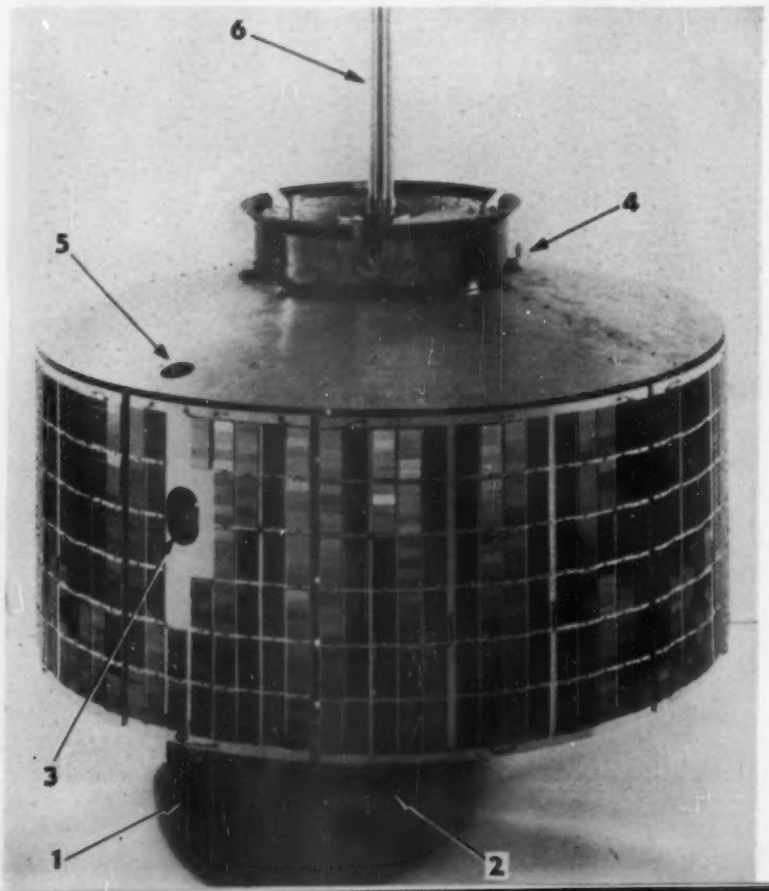


COMMUNICATION satellite appears with cross sectional view of Scout vehicle (center and left). Dimensions are indicated at right. Points of interest include (1) jettisonable nose cone, (2) orientation nozzle, (3) nitrogen tanks, (4) folded antenna, (5) fifth stage rocket, (6) fourth stage motor, (7) separation clamp, (8) thrust cutoff separation ring, (9) avionic unit, (10) velocity control nozzle, (11) sixth stage rocket.

Hughes Communication Satellite Detailed

OPERATING prototype of the Hughes communication satellite. Features include (1) sun sensors, (2) apogee rocket, (3) velocity control jet, (4) orientation control jet, (5) compressed gas jet fuel filler, (6) slotted array S-band antenna.



By Barry Miller

Culver City, Calif.—First details of a lightweight, potentially inexpensive active communication satellite capable of relaying up to 600 two-wire telephone messages over transcontinental distances were revealed last week by Hughes Aircraft Co.

The company also made known precisely how it could boost this communication repeater (AW Oct. 17, p. 26) into a 22,759 naut. mi. stationary orbit using a modified National Aeronautics and Space Administration four-stage solid-propellant Scout vehicle launched from an uninhabited equatorial island in the Pacific Ocean.

Combining simplified control concepts and integrated avionic techniques, Hughes scientists constructed an operating prototype of a spin-stabilized communication satellite. This wideband communication transponder accepts UHF signals and retransmits them in S-band. The payload can be placed into an inclined synchronous orbit (24-hr. orbit) by a Thor-Delta booster fired from Cape Canaveral, Fla.

After separation from its final stage—a special apogee rocket—the Thor-Delta payload weighs 52 lb. A similar Scout version is still lighter—it would weigh 32 lb. after apogee rocket fuel is exhausted.

Hughes is one of a growing number of companies (AW Oct. 31, p. 32) at-

TOP OF central canister of communication satellite is removed during checkout. At right engineer checks out Thor-Delta prototype of Hughes satellite. Orientation and velocity control jets are visible (1) and (3), solar sensors (2), filler for nitrogen gas (4).

tracted to the feasibility of economical relaying of quantities of telephone-telegraph messages, as well as television, across continental distances by earth satellites.

NASA's recent decision to make boosters, range and tracking facilities for satellite launchings available at cost to industry-financed commercial ventures stirred many companies to take a good hard look at what might be an extremely attractive undertaking. The Hughes studies and design effort predate NASA's announcement by more than a year and are directed to military, scientific as well as commercial applications of communication satellites. The company's efforts reached a high point recently during the engineering of the Thor-Delta payload, drawing at that time on the combined talents of about 50 persons in the Hughes organization.

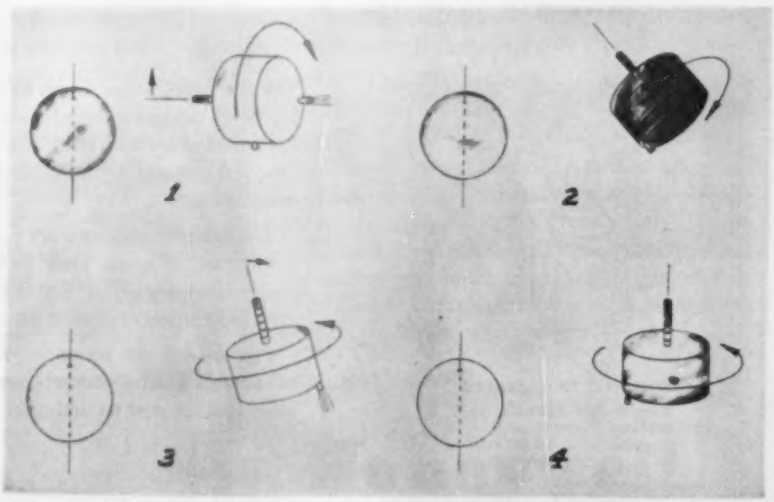
A communication satellite operating in a stationary earth orbit offers these advantages, cited by Dr. Harold A. Rosen, manager of the satellite project:

- **Coverage of vast areas** because of the great height of the orbit (22,752 naut. mi.).
- **Use of stationary reflectors** at ground terminals, thus minimizing cost. A report prepared by Rosen on some aspects of the stationary satellite was presented before the American Rocket Society in Washington last week.

Synchronous orbits make directional satellite antennas necessary, however, to conserve power and to cover the great ranges involved. Normally, Rosen says, directivity suggests a pencil beam antenna properly oriented by an attitude-stabilized payload and complex attitude and vernier velocity control. This in turn means more weight, a larger, more expensive booster and with it launching from a non-equatorial site. This additionally complicates the boost into orbit, the project costs swell and the launching becomes subject to tight missile range scheduling.

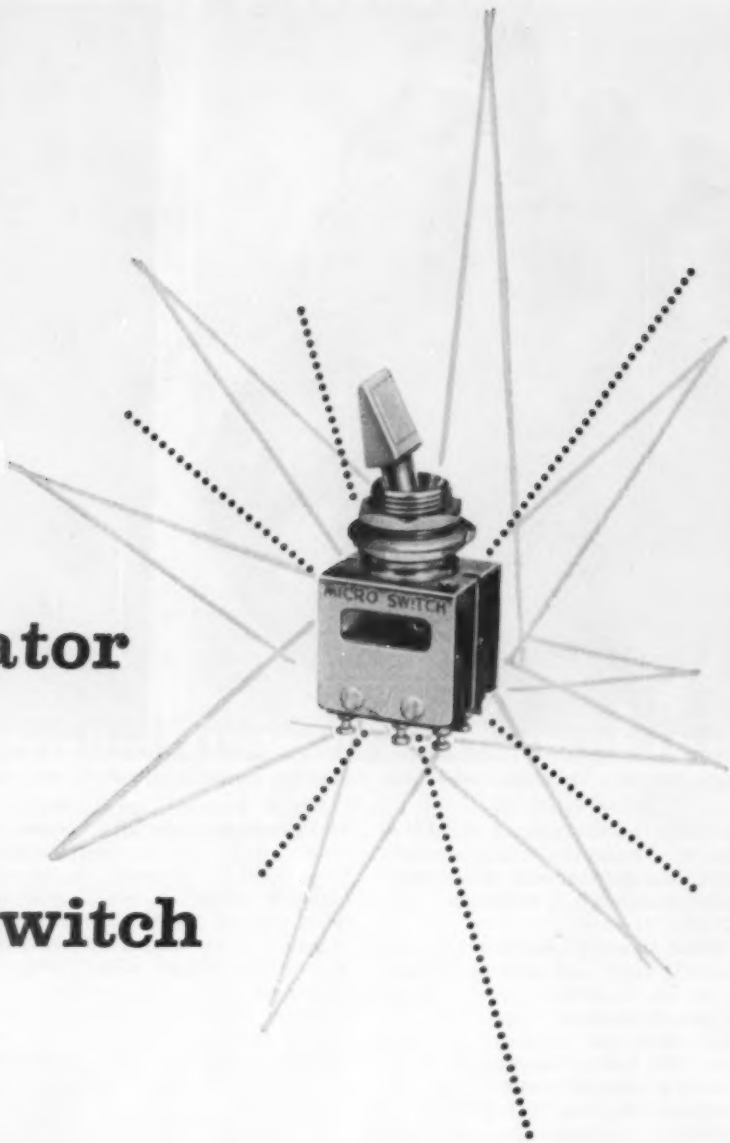
Colinear Slot Array

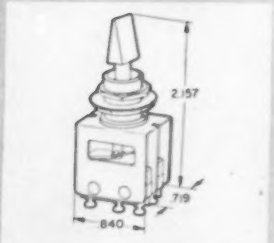
The Hughes design employs a colinear slot array antenna whose pattern is a figure of revolution about the spin axis. It permits spin stabilization of the satellite. Maximum gain (8 db.) is realized in the circular plane normal to the



COMPRESSED gas jet reorients satellite after latter is inserted into nominally synchronous orbit so that spin axis parallels the earth's axis.

New Tab-Indicator Toggle Switch





"400" SERIES TOGGLE SWITCHES
Five models available, including 2-position and 3-position types. All are rated at 5 amperes, 250 vac.

The new "400" Series Toggle Switch from MICRO SWITCH has a paddle-shaped tab which can be numbered or color-coded as an indicator. The standard model has a natural metallic finish which will maintain a fresh appearance through long and constant use. The anodized aluminum tab is also available in black or in colors.

The basic switches used are precision snap-action, long-life units, requiring a minimum of space. They conform to specifications for MIL-S-6743, with two isolated single-pole double-throw circuits. Turret terminals make wiring easy, and contact enclosures are dust-tight.

Five models are presently available in the "400" Series, including both momentary and maintained contact types. Write for Data Sheet No. 174 describing these new tab-indicator toggle switches.

75 YRS. HONEYWELL ENGINEERING THE FUTURE

MICRO SWITCH Precision Switches

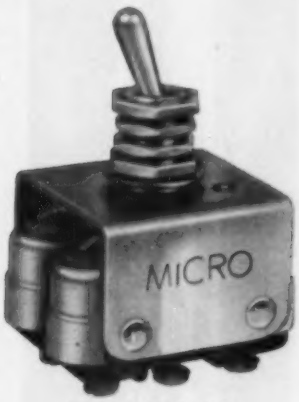
"1TL" Series

"4TL" Series

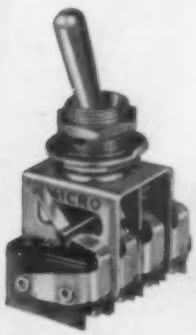
"1TL" Pull-to-Unlock

1-Pole "TS"

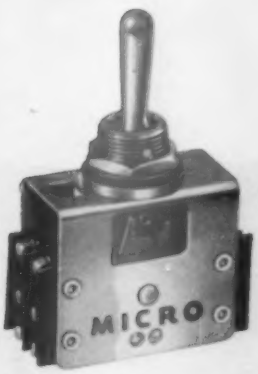
2-Pole Sealed "TS"



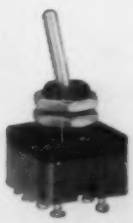
Hermetically Sealed Assembly



4-Switch Assembly



"Electrical Memory" Assembly



Subminiature "TM"

Precision Toggle Control Can Be Customized

MICRO SWITCH manufactures hundreds of different toggle switches and toggle switch assemblies. In this complete line you can find the exact characteristics and contact arrangements you need.

"TL" Series Silicone sealer between cover and case seals against dust or moisture. These switches are approved under MIL-S-3950A, operate in a temperature range of —85°F to +250°F. Available in 1, 2 and 4-pole models with integral terminals.

"TS" Series The toggle lever is sealed against dust and moisture. "TS" toggles meet specifications for MIL-S-3950A. Special plastic barrier plus extra distance between terminals. A keyed bushing prevents rotation. Wide choice of contact arrangements includes 1, 2, 3 and 4-pole types.

Subminiature "TM" Weighs only 4½ grams, measures only ½" x ½" at the base. Double-pole double-throw with wide temperature range and low circuit resistance.

"AT" Series Toggle Assemblies MICRO SWITCH offers toggle switch assemblies of up to 16 basic switches. Hermetically sealed types are also available.

There is a MICRO SWITCH branch office near you and prompt engineering help on the selection of toggle switches is available by simply checking the Yellow Pages. Be sure you get MICRO SWITCH precision and reliability.

WRITE FOR NEWLY REVISED CATALOG 73 ON TOGGLE SWITCHES

MICRO SWITCH . . . FREEPORT, ILLINOIS
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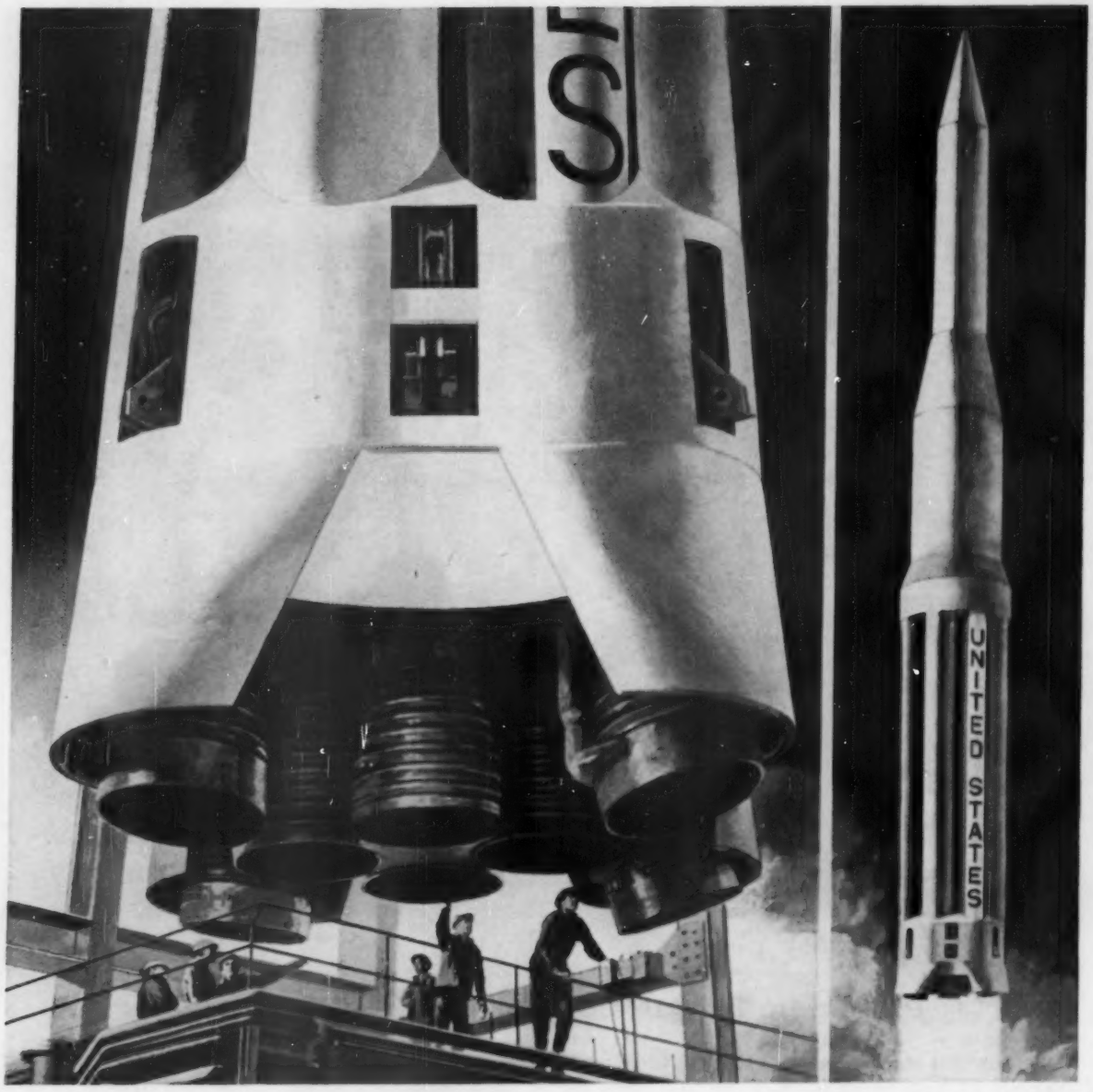
MICRO SWITCH Precision Switches



The first version of *Saturn* will be 185 feet tall . . . 21 feet across the base . . . will contain 14 rocket engines!

Douglas-built second stage is as tall as a 5-story building.

The rocket that will lead the way to space travel is now in development

Space researchers at Douglas Aircraft are already working on the design and construction of the second stage of the huge NASA *Saturn* rocket.

Saturn is the first program which is designed, from the ground up, to provide the capability of putting tons of payload into orbit or thrusting manned capsules beyond the earth's pull. It will initially be able to orbit 20,000 pounds around the earth, or deposit 6,000 pounds on the moon.

Future configurations of *Saturn* will have even greater thrust and payload, paving the way for round trips to the planets.

Fantastic as these predictions sound, they are the solid convictions of the men at Douglas whose skills have been behind the production of nearly 30,000 rockets, missiles and space vehicles. These include the *Thor* IRBM which has boosted more successful space payloads than all other U.S. boosters combined.

DOUGLAS

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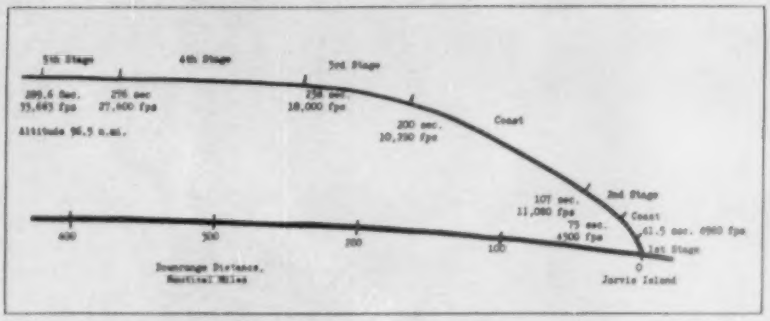
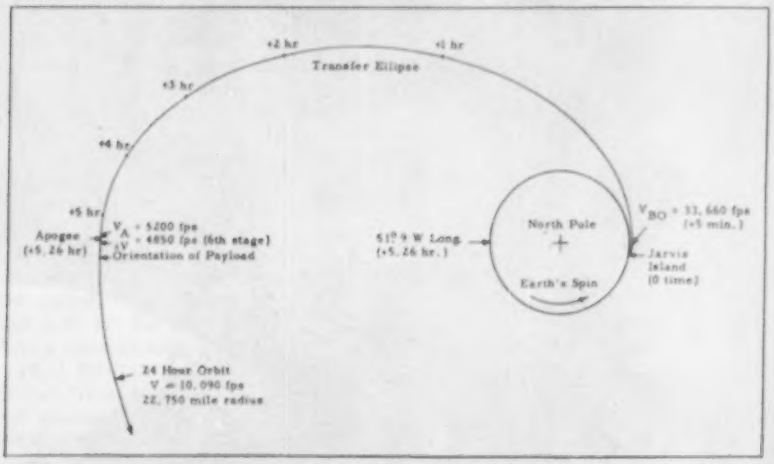


LIGHTWEIGHT communication satellite designed by Hughes could be boosted into equatorial plane by a NASA Scout vehicle launched eastward from Jarvis Island in the Pacific.



APOGEE rocket supported by central canister of satellite provides extra thrust to put satellite into nominally synchronous orbit roughly five hours after launch.

spin axis and in the direction of the earth when the satellite is oriented. In its studies of more distant, second-generation communication satellites of this type, the company is examining a four-element phased array which may add another 6 db. of gain. A 14-db. figure would compare more favorably with the gain of a pencil beam.

Promising Applications

There are several promising applications for the lightweight, compact spin-stabilized satellite concept conceived by Rosen and his coworkers and matured to an actual hardware stage in the Thor-Delta version, according to Jack Ludwig, manager of the Hughes Space Systems Laboratory here. These include:

• **Real-time television relay** between stations employed in tracking deep space probes. A payload for this could be launched into an inclined synchronous orbit (approximately 22,000 naut. mi.) by a Thor-Delta booster from Cape Canaveral.

• **Atlantic Missile Range** communication coverage to augment or replace contact between stations now maintained by a combination of cable and microwave. The Hughes satellite in an inclined synchronous orbit could do this job.

• **Military communications** capable of handling the non-secure, but normally heavy military telephone traffic. This system, Ludwig says, would supplement and not compete with the projected Advanced Research Projects Agency-Signal Corps Project Advent.

Over the past year the company discussed and proposed such systems or variations of them to NASA and military agencies. Ludwig says it sounded out other companies, including International Telephone and Telegraph Corp., about the possibility of a joint commercial communication satellite system based on the Hughes satellite design concept. To date, however, the project remains internally funded at Hughes.

A 22,752 naut. mi. stationary orbit communication satellite is the most useful application for the Hughes spin-stabilized payload, Ludwig indicates. This application may, however, be some years away. In the meantime the company is exploring the high altitude nonstationary orbit applications. In addition, it will submit a proposal in a forthcoming, open NASA competition (AW Nov. 21, p. 34) for an active

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The program: MAULER, U.S. Army's newest automatic-firing air defense system, involving missile-firing vehicles transported by air and parachuted into battle areas. **Basic Burroughs contribution:** design and production of the miniaturized electronic computer systems which will provide radar data processing and computation for MAULER. Among special design features will be the Burroughs Logi-Mod packaging technique, to protect sensitive computer components from shock during air transport and parachute drop. **Behind the news:** Still another vote of confidence in Burroughs Corporation's Computence—total competence in computation—from basic research through production and field service to system management. Confidence in Burroughs performance, already proved in such vital programs as ATLAS, SAGE and ALRI.

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Mauler is being developed by Convair-Pomona, Convair Division of General Dynamics, for ARGMA, an element of the Army Ordnance Missile Command.

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Orbit Terminology

Among terms employed by Hughes scientists in describing possible communication satellite orbits are:

- Circular orbit—An orbit which describes a complete constant altitude revolution about the earth.
- Equatorial orbit—An orbit which occurs in the plane of the earth's equator.
- Synchronous orbit—An orbit with a period of 24 sidereal hours. There are many possible synchronous orbits.
- Stationary orbit—A circular, equatorial and synchronous orbit. In a stationary orbit, the satellite appears "stationary" with respect to any point on the earth's surface because the satellite's speed and altitude (22,752-naut. mi.) keep it in a fixed relation to points on the earth. Thus, synchronous and stationary are not synonomous, although a stationary orbit must be synchronous though the reverse need not be true.
- Inclined synchronous orbit—Specific example of a non-equatorial, hence non-stationary, synchronous orbit. In this case, orbit is inclined with respect to the equator. The satellite's orbital period is 24 hr., but points on the earth have a changing relation to it.

Fixed reflectors can be employed at ground terminals in conjunction with the stationary satellite because of the unchanging relation between them. Synchronous orbiting satellites presuppose use of tracking antennas.

satellite. This probably will be a lower orbit system.

The over-all payload, its dimensions and its avionic package are identical for the Thor-Delta and Scout versions. The satellite consists of two concentric cylinders, the outer one 28 in. in diameter and 13 in. in length. Outside surface of the larger cylinder is coated by 2,700 glass-covered silicon solar cells capable of providing 18 w. electrical power. Around the inner surface of the outside cylinder are toroidal compressed-nitrogen gas tanks which provide fuel for the payload's orbital orientation and velocity control jets and support the solar cell structure.

An inner cylinder or central canister houses an integrated avionic package and supports the antenna and an apogee rocket which supplies the final burst of thrust for placing the satellite into a nominally synchronous orbit. Struts connect the central canister to the outer cylinder.

Mounted atop the center of the central canister, the antenna folds back for launch into slots separated at 120-deg. angle around the canister top.

It can transpond guidance signals from this folded position during the launch.

The apogee rocket is attached to the

Space Electronics Corporation creates and constructs a wide variety of advanced electronic systems for the nation's missile and space programs. SEC is now responsible for fabricating the airborne and ground-based electronic systems for the USAF's most recent space booster. In its first flight relying on SEC electronic systems, it launched into successful orbit Courier 1B — the world's first active-repeater communications satellite. The booster:

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Qualified scientists and engineers are urged to direct their inquiries to the personal attention of Dr. James Fletcher, president.

POINTS OF DEPARTURE

THE STROMBERG-CARLSON SYSTEMS MANAGEMENT TEAM HEADS...???

We can't give you the details yet, but we can report that Stromberg-Carlson has been asked to head up the development program for a passive reconnaissance network. Stromberg-Carlson won the nod on the strength of its Core Concept of Systems management, which helped get the project off and winging in short order . . . and on its long-standing sophistication in all aspects of advanced electronics and communications, military and commercial.

in SYSTEMS MANAGEMENT:

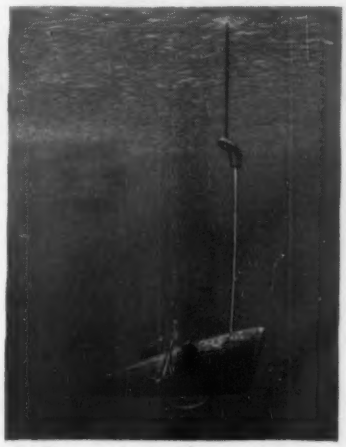
We're ready to launch your project as well—*now*. Because Core Concept maintains a permanent staff of top scientists, engineers, technicians, cost-scheduling and managerial talent, Stromberg-Carlson is always tooled up for any problems that arise within the rather extensive perimeters of its competence. Seasoned and dynamic, the Core Concept staff can line up contributing sub-contractor firms and get well underway on system projects of all types—in the time it previously took just to assemble a systems management group.

There's a very simple yardstick for measuring the speed and efficiency of Core Concept. Money. It's expected that Core Concept organization and administration can cut systems management cost significantly.

In what areas are we qualified? Well, we're involved in radar development for missile tracking systems. We've achieved several breakthroughs in solid-state circuitry and modularization of computer systems. We've had over 65 years in every phase of telephone communications. We produce radio sending and receiving equipment for land, sea, air and space. And we're right up there in high-speed teleprinters and electronic display techniques. Look on Stromberg-Carlson as a supermarket for systems, ideas and talent—to serve you.

FISHING FOR SUBMARINES . . . FROM THE AIR. SOME NEW IDEAS FROM S. C.

Efficient detection of underseas targets from swift-ranging aircraft will require new non-acoustic techniques. Stromberg-Carlson scientists think that a research program now in progress has important applications to these techniques. Under investigation are low-frequency electromagnetic phenomena, interplanetary plasma physics, and other geophysical processes which produce electromagnetic "noise."



in COMMUNICATIONS RESEARCH:

In present non-acoustic methods of detection from the air, the signal strength is frequently weak and always decays rapidly with distance; it soon disappears in the ever-present background noise.

Already, several signal processing techniques resulting from Stromberg-Carlson noise studies have been developed and tested. These show performance gains which promise to offset partially the loss in signal with distance through more effective discrimination against background noise.

The investigation of geophysical and astrophysical phenomena will include study of electromagnetic background noise at the earth's surface in the frequency region of 0.001 to 10,000 cps, solar radio signals and the interplanetary medium. Knowledge in this field of interest is growing rapidly, and worthwhile scientific contributions resulting from the planned work are almost certain.

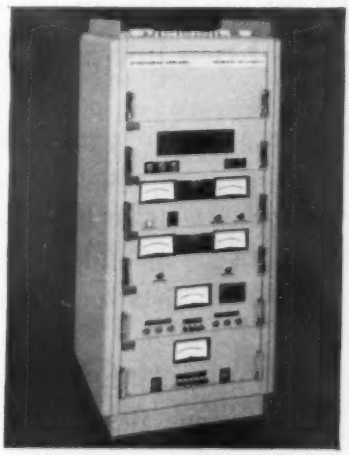
In the course of investigation, Stromberg-Carlson scientists also propose to determine the relationship between the characteristics of the earth's surface and the low-frequency electromagnetic background and to examine the noise spectrum for types of signals hitherto unknown.

This program is only one of Stromberg-Carlson's numerous basic research projects currently underway in all areas of electronics and communications.

FOR NUCLEAR REACTORS . . . MORE HOURS OF POWER EVERY MONTH

With Stromberg-Carlson's new completely solid-state modularized control systems, nuclear reactors put in significantly more operating hours every month.

While attending to their main functions—monitoring and controlling power level, rate of change of power level, pressure, temperature, and coolant flow—Stromberg-Carlson control systems check themselves continuously. Malfunctions are rare, but if one occurs, scram rods drop and the address of the offending part is flashed on the annunciator. Even an unskilled operator can then pull the module containing the flaw and plug in a replacement—all in a matter of minutes. Previously, it took hours, even days, to get a nuclear reactor back into operation.



in ELECTRONIC EQUIPMENT:

But this is merely the spectacular phase. More mundane, but more to the point in reducing reactor down time, is the simple fact that malfunctions *are* so rare.

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Right now, Stromberg-Carlson control systems are used with Detroit Edison's Enrico Fermi reactor . . . and will handle the Army's Ice Cap reactor — a portable, skid-mounted unit that will feed power to a Dew Line station in Greenland.

Stromberg-Carlson systems provide instrumentation throughout a reactor's entire operating range, from the moment of start-up. An overlap of two decades in the source, intermediate and power ranges assures continuous monitoring. Light and compact, these systems can control marine, portable, research, or commercial reactors.

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opposite end of the canister. Over-all height of the payload from tip of the erect antenna to end of the apogee rocket is 37.5 in.

The integrated avionic package provides these functions:

- **Communication repeater.**
- **Guidance signal repeater.**
- **Telemetering transmitter** and beacon.
- **Command receiver.**

Signal Reception

Communication signals, broadcast in the little-used portion of the UHF region, are received and mixed with a master oscillator signal. The resulting 45-mc. intermediate frequency signals are phase-modulated for power economy, then multiplied up to S-band and power-amplified in a specially designed Hughes traveling wave tube, now in development, before transmission back to earth. The latter will deliver 2.5 watts, provide 30 db. gain, weigh 8 oz., and operate with 33% efficiency. Its anticipated lifetime is 10,000 hr.

With the exception of the traveling wave tube, circuits employ solid-state components throughout.

The same transponder receives orientation and velocity jet commands, and signals which turn the transmitter and beacon on and off. Modulation of a separate 200-kc. oscillator by signals from two clam-shaped sun sensors, located on the bottom of the satellite, provides phasing information for firing of the orientation jet. Frequency of this oscillator is temperature dependent so readings of internal satellite temperature can be obtained at the guidance terminal. Frequency of a second nominally 200-kc. oscillator, which is a function of voltage, provides monitoring of battery voltage level.

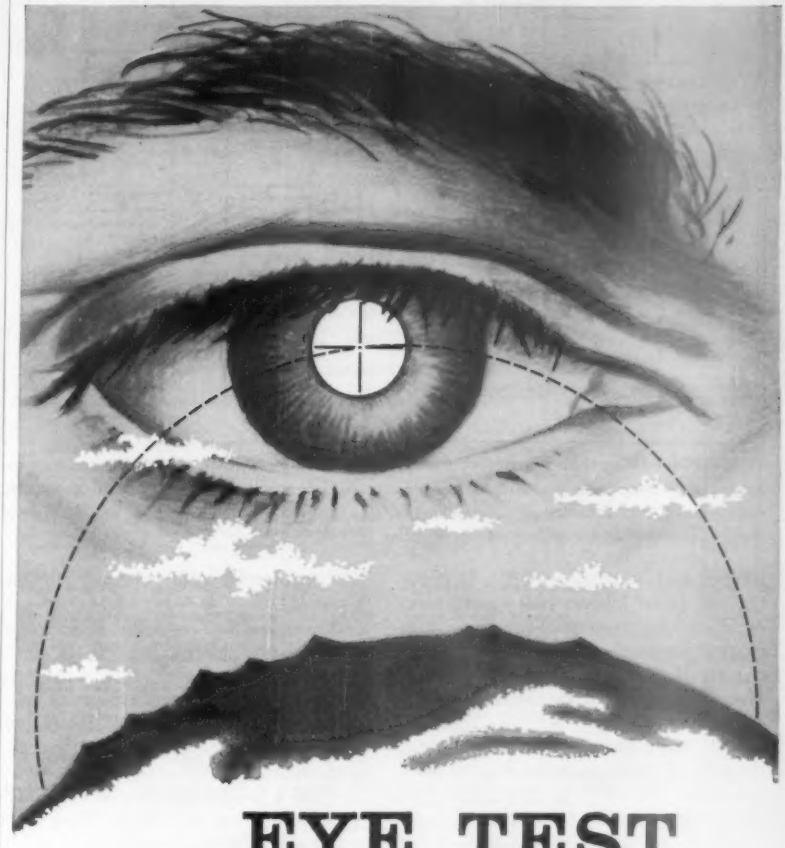
Weight of the avionics package is 6½ lb., including ½ lb. consumed by the traveling wave tube, ½ lb. for the antenna and 4½ lb. for avionic components. Hardware and antenna mounting account for the difference.

Avionic Power Supply

The total system requires 15 w., thus allowing a 3-w. cushion below solar cell capability. Two pounds of batteries supply power to the avionic gear during launch and pulsing of the orbital control jets. The transmitter of a stationary communication satellite would be turned off during eclipses, a total of 66 min. per year, Rosen points out.

The payload is capable of relaying up to 600 two-wire or 300 four-wire messages or one television channel. It can accept inputs from any number of ground stations on a frequency-division basis. Base bandwidth is 4.5 mc., voice channels are 4 kc.

For an equatorial launch of a stationary satellite by a lightweight booster (such as Scout or perhaps Air Force



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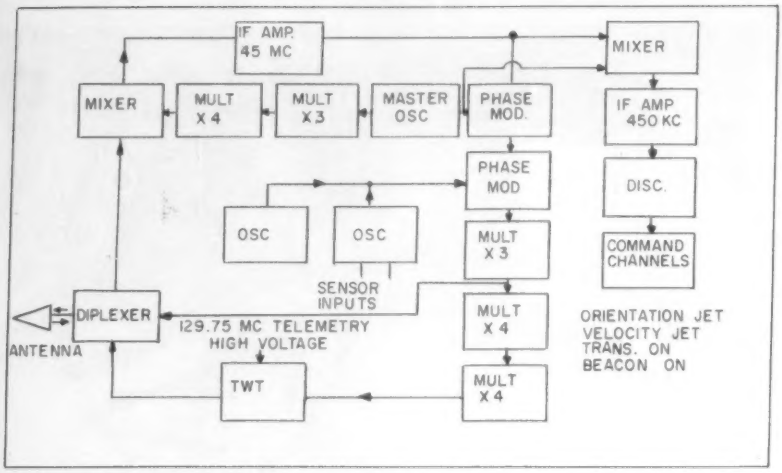

TRANSPONDER within Hughes communication satellite, shown in block diagram, can receive and retransmit up to 600 two-wire or 300 four-wire messages across continental distances. Entire avionics package weighs 6½ lb.; it will also telemeter data, receive ground-based commands and handle guidance signals.

Blue Scout), Hughes scientists have settled on Jarvis Island, two square miles of U. S. Department-of-Interior-administered property situated slightly below the equator, about 1,300 mi. south of Honolulu. Besides the attractiveness of a deserted location for an equatorial launch, the island also offers hundreds of miles of down-range (eastward) open-sea areas. Launched from this spot, the payload, were it to attain stationary orbit, would be located at 51.9 deg. west longitude, Rosen says.

Successful orbiting over the equator at this point would place the satellite over Brazil above an area near the coastal city of Belem. A locus of all geographical points within communication distance from this single satellite encompasses most of North and South America, Western Europe and Africa on an arc from Benghazi to Capetown. If this plan were followed, Hughes is thinking initially of two fixed-antenna ground stations, one in the Los Angeles area, the second probably in France or Belgium.

Fifth Stage Velocity

The payload would be launched into an equatorial plane, injected into a transfer ellipse after burnout of a fifth stage rocket (a state-of-the- art modification or addition to the Scout four-stage rocket) and, after coasting to apogee, would be injected into a nominally synchronous orbit. The fifth stage supplies additional velocity and contains the velocity cutoff mechanism.

Launch sequence for the 150-lb. gross payload (including fifth and sixth stage, or apogee, rockets) was outlined by Rosen as follows: Vehicle is launched eastward from Jarvis Island. After third-stage burnout it spins since it no longer is attitude-controlled as are the first stages.

Fourth stage and payload are spin stabilized.

A single-plane doppler interferometer guidance system, located on Jarvis, measures the vehicle's altitude and velocity. At the appropriate moment, a ground command cuts off thrust and the fifth stage separates from the payload.

The antenna erects during fifth-stage separation and the payload enters a transfer ellipse. It coasts for 5 hr. 16 min. until reaching apogee where the sixth stage, which supplies additional velocity for injection into a nominally synchronous orbit, fires on command. In an accompanying cross sectional view of the Scout payload, the apogee rocket appears to be in a reverse position. The velocity vector of the payload, however, undergoes a 180 deg. change from perigee to apogee to properly orient it for final sixth-stage burst.

In nominally synchronous orbit, the payload spins about its cylindrical axis, which is in the equatorial plane. An orientation or torquing gas jet, whose thrust axis is parallel to the spin axis of the satellite but displaced from the payload's center of gravity, then precesses the satellite 90 deg. to make its spin axis parallel to the earth's. Operating under ground command in the pulse mode, the jet torques the payload over 90 deg. to place it in the proper plane.

Subsequently, it can be operated in a continuous wave mode to produce thrust perpendicular to the equatorial plane to correct for inclination errors.

Proper phasing of ground-command pulses for jets, is provided by the two clam-shaped sun sensors.

The plane of sensitivity of one sensor passes through the satellite's spin axis and determines spin phase, while the plane of sensitivity of the second sensor is tipped 35 deg. with respect to the first and is used to determine angle of the sun relative to spin axis of the satellite. With this spin angle information, telemetered from payload back to ground guidance station, a synchronous controller generates commands for the orientation and velocity jets.

A second control jet, whose thrust axis passes through the payload's center of gravity and is normal to the spin axis, provides velocity correction. On command, this velocity jet can increase orbiting velocity. The torquer jet, operating in its cw mode, corrects for inclination changes.

Satellite Lifetime

After a stationary orbit is achieved, jet control can be maintained for limited periods. Velocity capability of the two nitrogen tanks is about 250 fps., Rosen estimates. Lifetime of the satellite is limited to about one year by solar cell degradation and gradual inclination build-up of 1 deg. a year which eventually places payload out of control.

Rosen calculates that satellite launch has 100% probability of achieving synchronism, 50% probability of being stationary.

Intercontinental communications would be possible using only a single stationary satellite backed up by one spare in orbit. Any number of ground terminals could be tied in. The spare satellite could relay TV and, in the event of failure in the main satellite, the spare could switch over to telegraph/telephone relay.

The operating prototype designed for Thor-Delta launch differs in several

Man-in-Space Contracts

Edwards AFB, Calif.—Contract for a 12-channel biological telemetry system (AW Nov. 21, p. 23) capable of transmitting a pilot's physiological responses during flights of vehicles like the X-15 and Dyna-Soar, was awarded last week to Hughes Aircraft Co., Culver City, Calif. Value of the award was placed at $78,698.

This is the second in a series of four awards to be made by the Air Force Flight Test Center for instrumenting man-in-space environments.

A $47,100 contract for a pressure gas sensor is about to be awarded and a contract for a blood pressure measuring device, fourth contract in this series is expected in the near future.

First contract in the series went to Spacelabs, Inc., Van Nuys, Calif., late in October. Under this $23,579 contract, Spacelabs will build a breathing study device to measure man's respiration rate and depth in a full pressure suit.

respects from the Scout version. Thor Delta version is heavier, employs four toroidal steel tanks filled with compressed nitrogen required by the control jets. It weighs 118 lb., including what for Thor-Delta would be the fourth stage, the apogee rocket. After apogee-rocket burnout, and separation of rocket case, weight in orbit is 52 lb. Gross weight of the Scout payload, including five-stage rocket and six-stage apogee rocket is 150 lb. After separation of the fifth stage, and burnout of the apogee rocket (the apogee rocket itself does not separate from the satellite in this version), the Scout-boosted satellite weighs 32 lb. Part of the weight reduction in the Scout version is made possible by less demand on jet supply. Supply for this version is contained in two titanium toroidal tanks.

Guidance System

The satellite's guidance system, a single-plane doppler interferometer system, would be situated on Jarvis Island. It consists of an 800 w. UHF guidance and command transmitter, a nearby S-band receiver, both equipments on gun mounts, and an angle tracking S-band receiver displaced about two miles on a tracking pedestal to form an interferometer.

The two receivers, each of which has a 10-ft. dish, measure range rate, range, elevation angle and elevation angle rate.

At the first receiver an analog computer solves necessary linear equations and computes cutoff time.

The transmitter signals for thrust cutoff, commands apogee rocket firing, orientation and velocity jet operation, and satellite transmitter turn-on and turn-off during transfer ellipse and eclipses. Total cost of instrumenting the island, including preparation of a 5,000 ft. C-130 runway on the island, would be less than the range cost for firing a single large booster from Cape Canaveral.

Transporting personnel to and maintaining them at Jarvis would increase this considerably, however.

Project Leaders

A number of engineers and scientists at Hughes pooled their talents in analyzing, designing and engineering the satellite project. Among them were Tom Hudspeth, responsible for the avionic design, Don Williams, orientation method and dynamic analysis of the entire system, Ralph Colbert, supervision of the structural design and integration of units, and Ed Marriott, a project manager for mechanical and thermal design of the payload.

Besides completing the Thor-Delta payload, Hughes has finished the transmitter and analog computer and has breadboarded the receiver.

Air Force Research Grants

Washington—Contract awards and grants for basic scientific research in universities, nonprofit institutions and industrial laboratories made by Air Force Office of Scientific Research since Aug. 1 total $3,639,271. Contracts and grants are as follows:

Contractor	Date Work Started	Short Title	Estimate of Cost
Behavioral Sciences			
Ohio State Univ., Columbus, Ohio	Aug., 1959	Personality Factors in Motivation	$28,609
Univ. of Georgia, Athens, Ga.	Nov., 1959	Technological Changes Impact on Careers	50,095
Mass. Mental Health Cntr., Boston, Mass.	Aug., 1959	Hypnosis as a Contro	58,349
Ohio State Univ., Columbus, Ohio	Apr., 1958	Situational Variables	65,400
Biological Sciences			
Univ. of Calif., Berkeley, Calif.	May, 1959	Brain Tolerance to Space Environment	38,338
RIAS Division, Baltimore, Md.	Aug., 1960	Photosynthesis	57,193
Chemical Sciences			
Columbia Univ., New York, N.Y.	Aug., 1960	Microwave Spectroscopy	41,074
Univ. of Calif., Berkeley, Calif.	Feb., 1960	Chemical Effects of Radiation	110,000
Purdue Res. Found., Lafayette, Ind.	June, 1960	Properties of Silyl Radicals	57,473
Univ. of Wash., Seattle, Wash.	July, 1960	Boron and Silicon Compounds	44,000
Wash. State Univ., Pullman, Wash.	Feb., 1959	Pyrolysis of Esters	32,998
Univ. of Calif., Berkeley, Calif.	July, 1960	Molecular Spectroscopy	54,002
Rensselaer Poly. Inst., Troy, N.Y.	June, 1960	Surface-Catalyzed Excitation of Atoms	114,700
Southern Research Inst., Birmingham, Ala.	Oct., 1958	Diffusion of Iron	41,320
Northwestern Univ., Evanston, Ill.	June, 1960	Catalysis in Liquids	26,000
Kent State Univ., Kent, Ohio	Mar., 1959	Electrolytes in Acetic Acid	12,392
Tufts, Univ., Medford, Mass.	Dec., 1957	Intermediates in Ozonation	14,860
Univ. of N. Hamp., Durham, N. Hamp.	Jan., 1958	Organoboron Chemistry	14,400
Johns Hopkins Univ., Baltimore, Md.	May, 1956	Microcatalytic Techniques	12,063
Northwestern Univ., Evanston, Ill.	Jan., 1958	Platinum Metal Compounds	14,550
Univ. of Oregon, Eugene, Oreg.	July, 1958	Surface Chemistry of Nonpolar Molecules	15,730
Cornell Univ., Ithaca, N.Y.	July, 1960	Diels-Alder Reaction	22,916
Univ. of Kansas, Lawrence, Kan.	July, 1960	Transport Processes (grant)	43,460
Johns Hopkins Univ., Baltimore, Md.	June, 1958	Free Radicals & Reactive Molecules	28,558
Univ. of Minn., Minneapolis, Minn.	Oct., 1958	Non-aqueous Polarography & Amperometry	25,820
Princeton Univ., Princeton, N.J.	June, 1958	Photonometric Titrations	56,400
Poly. Inst. of Brooklyn, N.Y.	Jan., 1958	Adsorption of High Polymers	17,834
Indiana Univ., Bloomington, Ind.	Jan., 1958	Electrochemistry of Fused Salts	15,212
Poly. Inst. of Brooklyn, N.Y.	Dec., 1957	Photochemical Reactions	24,565
Mathematical Sciences			
Univ. of N. C., Chapel Hill, N.C.	June, 1960	Linear Mixed Models	35,520
Inst. for Adv. Study, Princeton, N.J.	June, 1957	Advanced Mathematics	48,500
Carnegie Inst. of Tech., Pittsburgh, Pa.	Mar., 1960	Conformal & Variational Methods	56,895
Mechanics			
N. Amer. Aviation, Downey, Calif.	June, 1957	Laminar Boundry Layer Stability	62,662
Cornell Aero. Lab., Buffalo, N.Y.	Aug., 1960	High-Temperature Phenomena	79,994
Univ. of Minn., Minneapolis, Minn.	Dec., 1958	Mass Transfer Cooling	40,000
Univ. of Md., College Park, Md.	Mar., 1959	Boundry Layer Instability	41,300
Stanford Univ., Stanford, Calif.	Apr., 1957	Thermal Effects in Aircraft Structures	82,863
Cornell Univ., Ithaca, N.Y.	Nov., 1958	High-Speed Aerodynamics	74,588
Martin Co., Baltimore, Md.	Aug., 1960	Vacuum Environment & Materials	40,714
General Dynamics, San Diego, Calif.	Jan., 1958	Hydrogen-oxygen Interactions	83,403
Poly. Inst. of Brooklyn, N.Y.	Apr., 1957	Hypersonic & Low-Density Flow	243,000
Poly. Inst. of Brooklyn, N.Y.	May, 1958	Vibrations of Cylindrical Shells	26,000
Stanford Univ., Stanford, Calif.	Mar., 1957	Irreversible Processes	37,105
Univ. of Calif., Berkeley, Calif.	Aug., 1958	Low-Density Wind Tunnel	150,000
Cornell Aero. Lab., Buffalo, N.Y.	Oct., 1959	High-Temperature Gas Flows	49,809
Cornell Aero. Lab., Buffalo, N.Y.	Oct., 1959	Nonequilibrium Flows	51,600
Cornell Aero. Lab., Buffalo, N.Y.	Oct., 1959	Molecular Interactions	99,968
Univ. of Minn., Minneapolis, Minn.	Feb., 1957	Heat Transfer at Hypersonic Speeds	40,000
Mass. Inst. of Tech., Cambridge, Mass.	June, 1960	Unsteady Gasdynamics in Flight Vehicles	40,750
Vitro Laboratories, West Orange, N.J.	July, 1958	High-Intensity Arc Plasma	42,070
Midwest Rsch. Inst., Kansas City, Mo.	Feb., 1958	External Force on Panel Flutter	37,800
Poly. Inst. of Brooklyn, N.Y.	Apr., 1958	Problems of Hypersonic Flow	125,000
Univ. of Toronto, Toronto, Canada	Dec., 1959	Magnetogasdynamics	9,693
Martin Co., Baltimore, Md.	June, 1960	Nonlinear Mechanics Symposium	9,000
Nuclear Physics			
Stanford Univ., Stanford, Calif.	Feb., 1958	High-Energy Electrons Scattering, etc.	150,000
Physics			
Northwestern Univ., Evanston, Ill.	July, 1960	Stellar Motion & Atmospheric Scintillation	43,823
New York Univ., New York, N.Y.	Jan., 1959	Control Systems	48,072
Stevens Inst., Hoboken, N.J.	Jan., 1958	Photon Spectroscopy	27,276
Columbia Univ., New York, N.Y.	Mar., 1959	Radio Astronomy	29,000
New York Univ., New York, N.Y.	Aug., 1957	Low-Frequency Absorption Spectra	15,076
St. John's Univ., Jamaica, N.Y.	July, 1960	Electron Collisions (grant)	29,900
Univ. of Minn., Minneapolis, Minn.	Feb., 1958	Gaseous Electronics	34,300
Columbia, Univ., New York, N.Y.	Sept., 1958	Infrared MASER	65,140
Columbia, Univ., New York, N.Y.	July, 1960	Radioactive Atoms	38,000
Yeshiva Univ., New York, N.Y.	Sept., 1959	Transport Properties	34,045
Princeton Univ., Princeton, N.J.	Dec., 1957	Stellar Evolution	6,336
Univ. of N. Hamp., Durham, N. Hamp.	May, 1959	Gaseous Plasmas and Solids	19,840
Propulsion			
Litton Industries, Beverly Hills, Calif.	Sept., 1959	Electromagnetic Plasma Accelerator	177,641
Princeton Univ., Princeton, N.J.	Mar., 1958	Ignition of Solid Propellants	53,000
Solid State Sciences			
Univ. of Colorado, Boulder, Colo.	Feb., 1959	Paramagnetic Impurities in Crystals	39,022
Univ. of Maryland, College Park, Md.	Mar., 1958	Solid-State Theory	38,016
Brown University, Providence, R.I.	July, 1958	Recrystallization	28,839
Univ. of Calif., Berkeley, Calif.	Aug., 1956	Stresses in Ceramic Bodies	33,400

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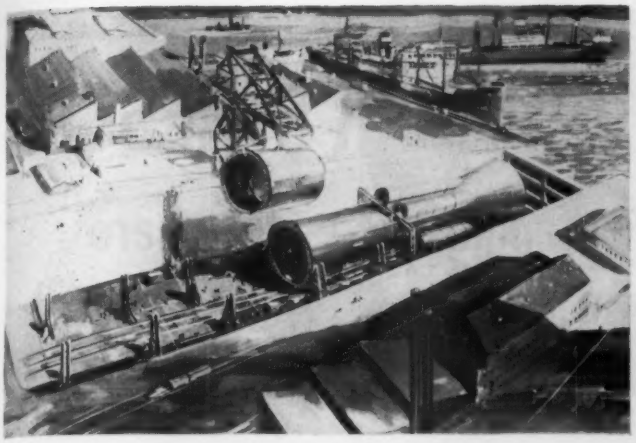

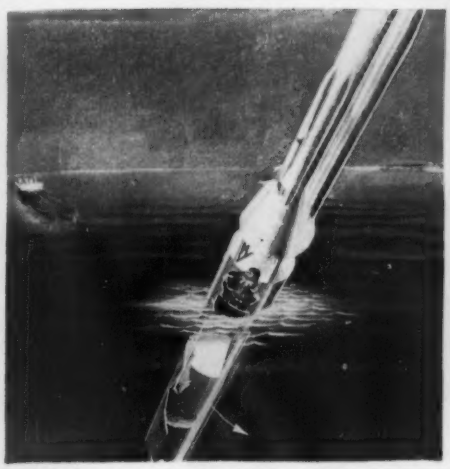

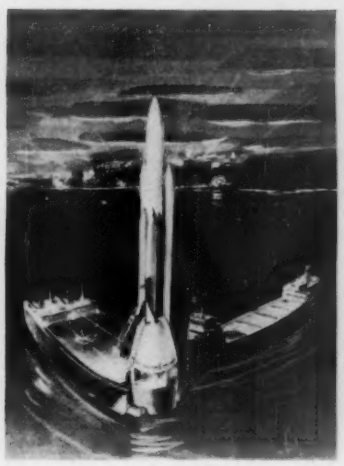

CONSTRUCTION of the three stages for a sea-launched space vehicle (top, left) takes place in drydock facilities. Drawing at top right shows booster and space vehicle being towed to the sea launch area. The booster and space vehicle are erected to launch position (below, left) by allowing sea water to flow into a section of the launching pontoon; arrow shows motion of erection. At center, the tender is floated into position. Drawing at right shows use of parachutes and retrorockets for recovery.

Sea Launch Studied for Space Vehicles

By Larry Booda

Washington—Interest in moving launch operations to sea is growing in military and civilian space organizations as the size of planned space vehicle boosters increases.

Air Force, Navy and National Aeronautics and Space Administration are considering the feasibility of establishing sea launch facilities for large boosters, and the concept conceivably could be extended to missiles. Economy and safety are the major gains involved in shifting to this new space launch technique.

Several companies have conducted sea launch studies, both on their own and with government funds. Some have worked alone, and others have teamed with shipbuilding firms to tap their experience. Proposals cover a variety of launch bases, including ships; ocean-going, partly-submerged floating platforms; towers anchored to the sea floor; floating booster-vehicle-pontoon combinations which can be erected after being towed to sea, and systems for launching from the sea floor.

These proposed systems could provide sea launch bases for:

- **Vertical probes.** They could be fired from a variety of locations around the world without the danger of damage as they fell back to earth.
- **Low orbit tactical** reconnaissance and attack satellites. They could be launched into any 100-200 mi. orbit without the dog-leg capability required with flights from fixed land bases.
- **Large tactical missiles,** such as Thor, Atlas, Titan and Minuteman. Sea launch would offer them mobility and concealment.
- **Large space boosters.** The new generation of chemically-powered boosters, such as Saturn and Nova, could be launched without the considerable expense of building new land installations.
- **Nuclear rockets.** Rover and other nuclear-powered rockets could be launched without radiation hazards to populated land areas.

Air Force expects to move development of sea launch systems beyond the study phase soon. With a requirement already established for an 800,000-lb. thrust booster under Project Phoenix (AW Dec. 5, p. 26), Air Force Ballistic Missile Division is interested in the mobility the sea launch concept offers with such a large space booster. USAF also is considering sea launch for the Csar communications satellite, which will be in a 24-hr. equatorial orbit.

Rand Corp. has had sea launch studies done for USAF by Wald Research, Inc., and the DeLong Corp. Thompson Ramo Wooldridge has proposed an offshore towable platform.

With its large vehicle programs not yet firm, NASA is interested in the sea

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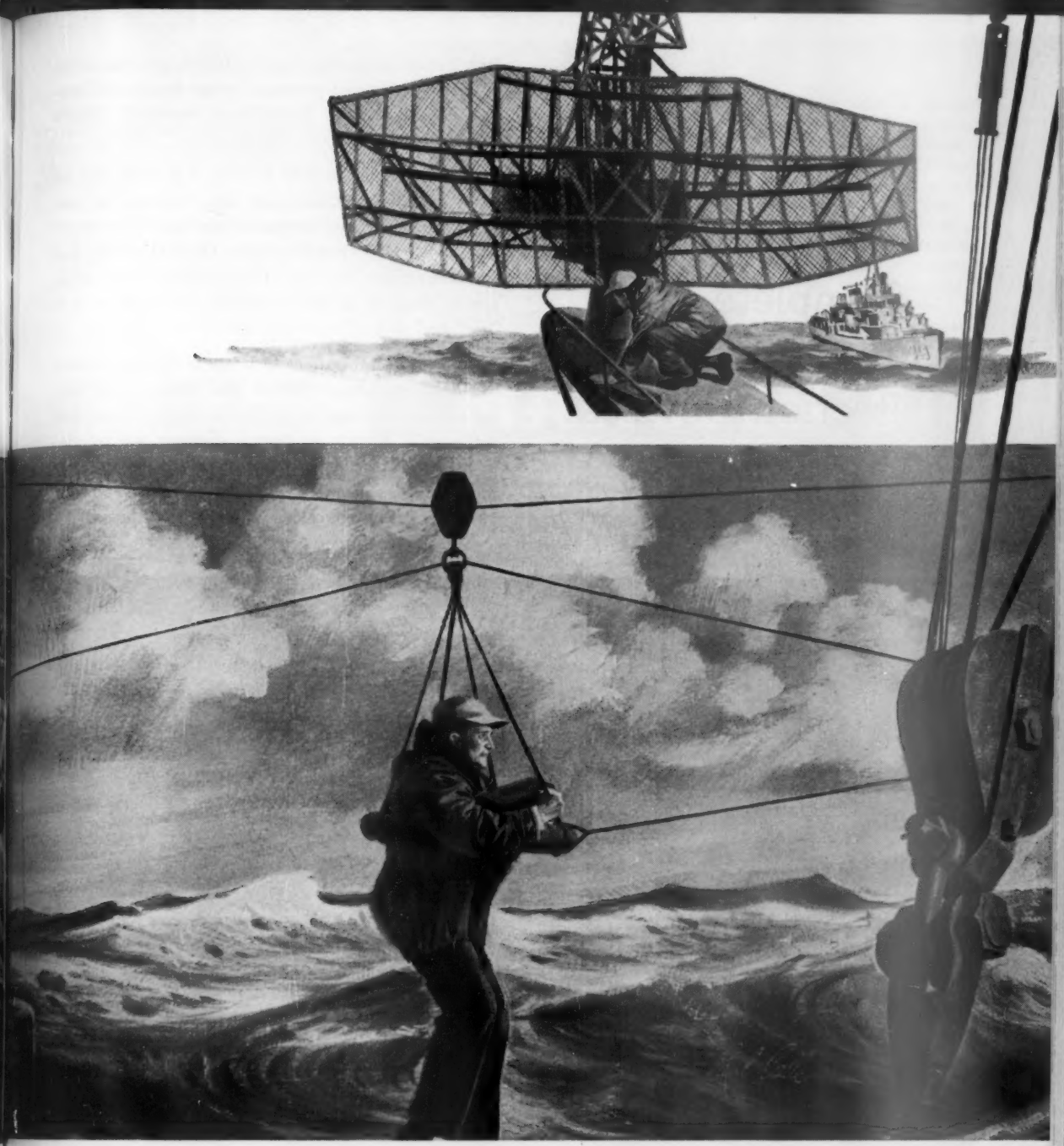

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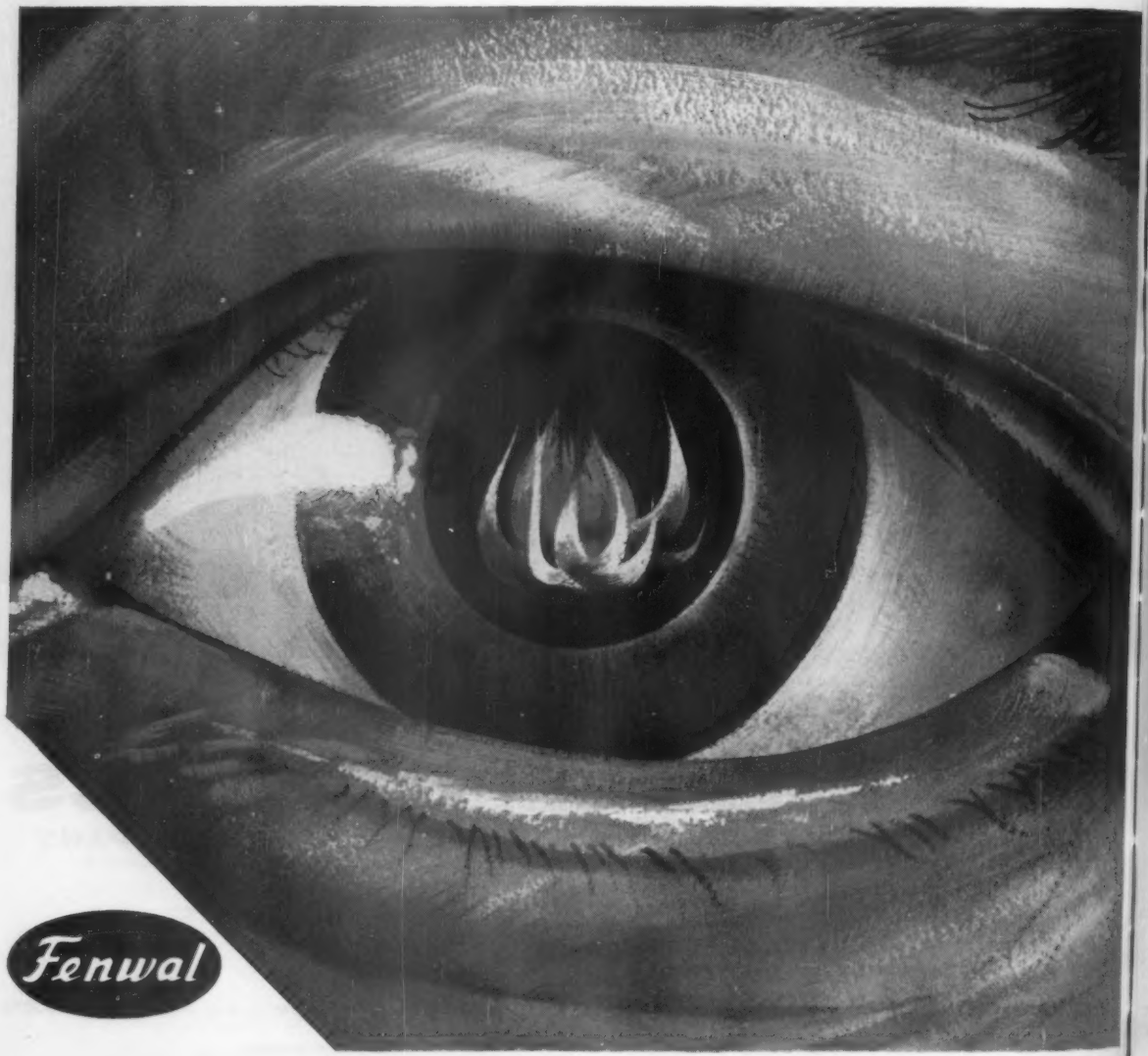

launch concept but has not generated any specific requirements. The agency's Nova vehicle will be powered by a cluster of large chemical boosters or a nuclear propulsion system, and NASA does not expect to produce a launch base requirement until it decides what kind of engines will power Nova.

Presentations of studies have been made to NASA by Cal-Val Engineering, teamed with Harbor Boat Building Co., Daniel, Mann, Johnson and Mendenhall (AW Sept. 12, p. 122), Kaiser Steel, American Machine and Foundry, and Aerojet-General teamed with Todd Shipyards.

Numerous advantages for launching at sea have been offered. Principal one is economy, since land installations are becoming more complex and expensive. Another is safety in case of failures by large chemical rockets and, later, nuclear-powered rockets.

For equatorial orbits, sea launch would permit the use of simpler guidance systems. If a vehicle is launched from Cape Canaveral, Fla. or Vandenberg AFB, Calif., a dog-leg would have to be added to the launching flight path to change the flight plane from one passing through the launch site to the plane of the equator.

Cost Estimates

Various estimates of the additional cost of dog-leg launches have been made, but the minimum estimate is 45-50%. Other estimates run three to five times the cost of the simpler guidance. Equatorial launch also could be made from a sea base without the expense of establishing a new land base on the equator.

In firing high-thrust powerplants, one high cost factor is the construction and operation of blast deflectors. In static testing, millions of gallons of water must be used for cooling. Water cooled deflectors and towers would be eliminated in sea testing and launching.

With military systems, the Navy advances the argument that mobility and secrecy are offered at sea for launching missiles and military satellites. Land sites, easily pinpointed by an enemy, would have to be considerably hardened for similar protection.

The coming of larger boosters brings a requirement for novel ways of constructing and handling them. Mobility will be reduced as the boosters become too large to be built at the manufacturer's plant and hauled to test and launch sites.

One answer to this problem is to assemble the booster at its launch site. Another is to build it near water so its size is not limited by road and rail facilities and it can be loaded directly on ships to be hauled to a sea launch site. Ships could accommodate the whole vehicle, or at least larger compo-

Marconi's offer a complete consultancy and engineering service in the installation of radar systems. All Marconi radars and data handling equipment have been designed for integration into the most advanced air traffic control and defense systems at present in operation or contemplated in the foreseeable future.
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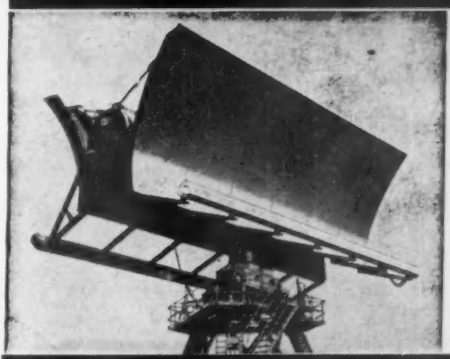

LONG RANGE SURVEILLANCE RADAR

This versatile radar can be adapted to a diversity of applications. The Moving Target Indicator eliminates the echoes from stationary objects. Distortion of the reflector profile is prevented by the main member being a 6′ 8″ diameter tube, thus giving increased accuracy over a longer life. A unique mechanical design feature ensures that the turning gear is unaffected by slight subsidence of the site. Like the S244 the equipment is 'all weather' and 'all climate' and will withstand wind speeds up to 120 knots without 'radoming'.

of ground radar

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The Marconi S244 is the most advanced and accurate height finder in the world. In conjunction with the Marconi control system it can handle 15 random targets per minute. Height references are related to a shock mounted artificial horizon which overcomes the instabilities inherent in all large supporting structures and gives the greatest known accuracy. The equipment operates satisfactorily in all weathers and climates from Arctic snows to tropical monsoon precipitation. It may be 'radomed' for protection but will withstand wind speeds up to 120 knots without 'radoming'.

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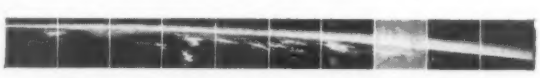
THE MISSILE RANGE: Measure of Capability

The missile range today is a vast proving ground for advanced technologies. It symbolizes the "state of the art" in computation, physics, chemistry, metallurgy, propulsion, hydraulics, electronics, inertial guidance, communications and every other scientific field.

The most critical need of the missile range is to *know system performance exactly*. This calls for integrated standards of measurement and data handling, and therefore for entire systems and entire installations engineered to that objective.

To this problem Sperry Rand has a logical answer: *compatible instrumentation*. The scope of Sperry Rand capability, illustrated above, embraces the whole panorama of the space age. Compatible Instrumentation is the principle of precision in missile range measurement, and a plan of action for applying this principle to projects now developing.

For the necessary team approach to missile range technology Sperry capabilities are joined with those of all other corporate divisions which have contributions to make—among them Ford Instrument Company, Remington Rand Univac, Vickers Incorporated and several component divisions specializing in microwaves, electronic tubes and solid state devices. General Offices: Great Neck, N. Y.



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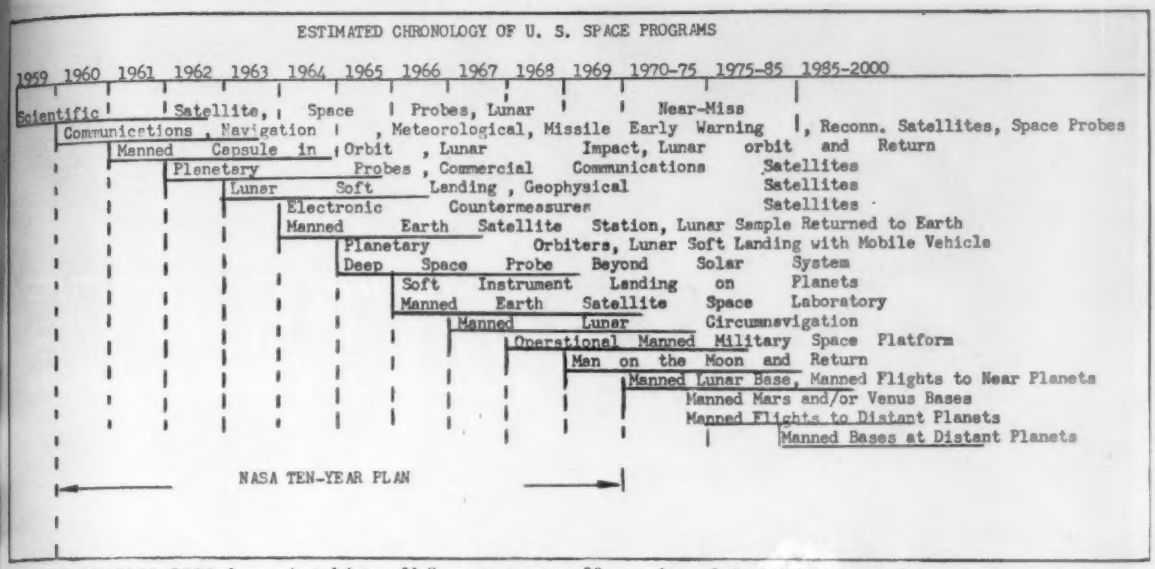
SPERRY


ESTIMATED CHRONOLOGY OF U. S. SPACE PROGRAMS
1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970-75 1975-85 1985-2000
Scientific Satellite, Space Probes, Lunar Near-Miss
Communications, Navigation, Meteorological, Missile Early Warning, Reconn. Satellites, Space Probes
Manned Capsule in Orbit, Lunar Impact, Lunar orbit and Return
Planetary Probes, Commercial Communications Satellites
Lunar Soft Landing, Geophysical Satellites
Electronic Countermeasures Satellites
Manned Earth Satellite Station, Lunar Sample Returned to Earth
Planetary Orbiters, Lunar Soft Landing with Mobile Vehicle
Deep Space Probe Beyond Solar System
Soft Instrument Landing on Planets
Manned Earth Satellite Space Laboratory
Manned Lunar Circumnavigation
Operational Manned Military Space Platform
Man on the Moon and Return
Manned Lunar Base, Manned Flights to Near Planets
Manned Mars and/or Venus Bases
Manned Flights to Distant Planets
Manned Bases at Distant Planets
NASA TEN-YEAR PLAN

AEROJET-GENERAL CORP. has projected future U. S. space programs 30 years beyond the NASA 10-year plan.

nents than could travel by rail or highway.

Typical of the proposals made to ARDC is that of Thompson Ramo Wooldridge. It calls for construction of an offshore platform which would be anchored to the sea bottom after it was towed to the launch area.

There would be pilings supporting an underwater substructure containing the control center for a launching. Above this would be a launching platform which could be replaced in the event of an accident, leaving the control complex unharmed. TRW proposal specifies about 150 of these platforms, to be built after development of the launch vehicles. Cost would be about $6 million each.

Different Approaches

Aerojet-General proposals include several different approaches to launching at sea. One includes an idea similar to the TRW tower. Another would make the entire rig capable of floating in deeper water and being towed anywhere the water is 400 ft. or more deep.

In preliminary company-funded work, Aerojet and Todd Shipyards have built a ship similar to a floating drydock which would carry a vehicle to sea in a horizontal position. On station, the launch vehicle would be erected, the ship would be partially submerged, then the vehicle would be launched. The size of this experimental ship would permit current boosters and those planned for the immediate future to be launched.

The principal concept studied by Aerojet, however, is known as PROP, for Planetary Rocket Ocean Platform, which is said to meet all the requirements for assembling, testing and launching very large vehicles. It is especially suited for launching of nuclear rockets, the company says, because of the isolation inherent in remote sea areas and the availability of unlimited quantities of sea water for nuclear shielding.

As proposed, PROP would accommodate a vehicle 40 ft. in diameter and 300 ft. long. The superstructure would be above the reach of high seas. It would be supported by buoyant chambers below the wave forces of such seas.

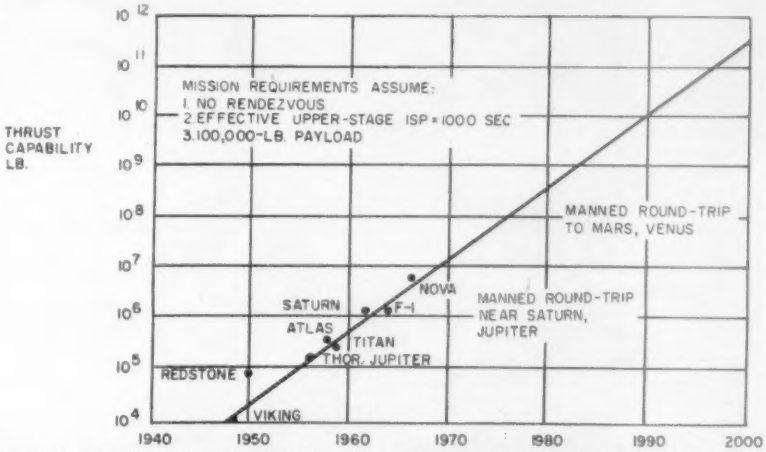
Logistic supply would be by ship. A shipboard crane would hoist the vehicle, housed in a protective cocoon, on deck. After removal from the cocoon, it would be let down into the central tube where prelaunch final assembly and checkout would be accomplished out of the reach of the weather. After preparation, vehicle would be hoisted to firing position on the platform.

After a normal nuclear launch, or in the event of a nuclear accident which would destroy the platform, personnel in the control areas in the buoyant outer ring 125 ft. below the surface would be evacuated by a submarine through an airlock. After a normal launch, a number of decontamination procedures would be carried out. Reconstruction after an accident would involve only the work on the platform and crane, and there would not be the radiation contamination that would normally have to be considered at a land installation.

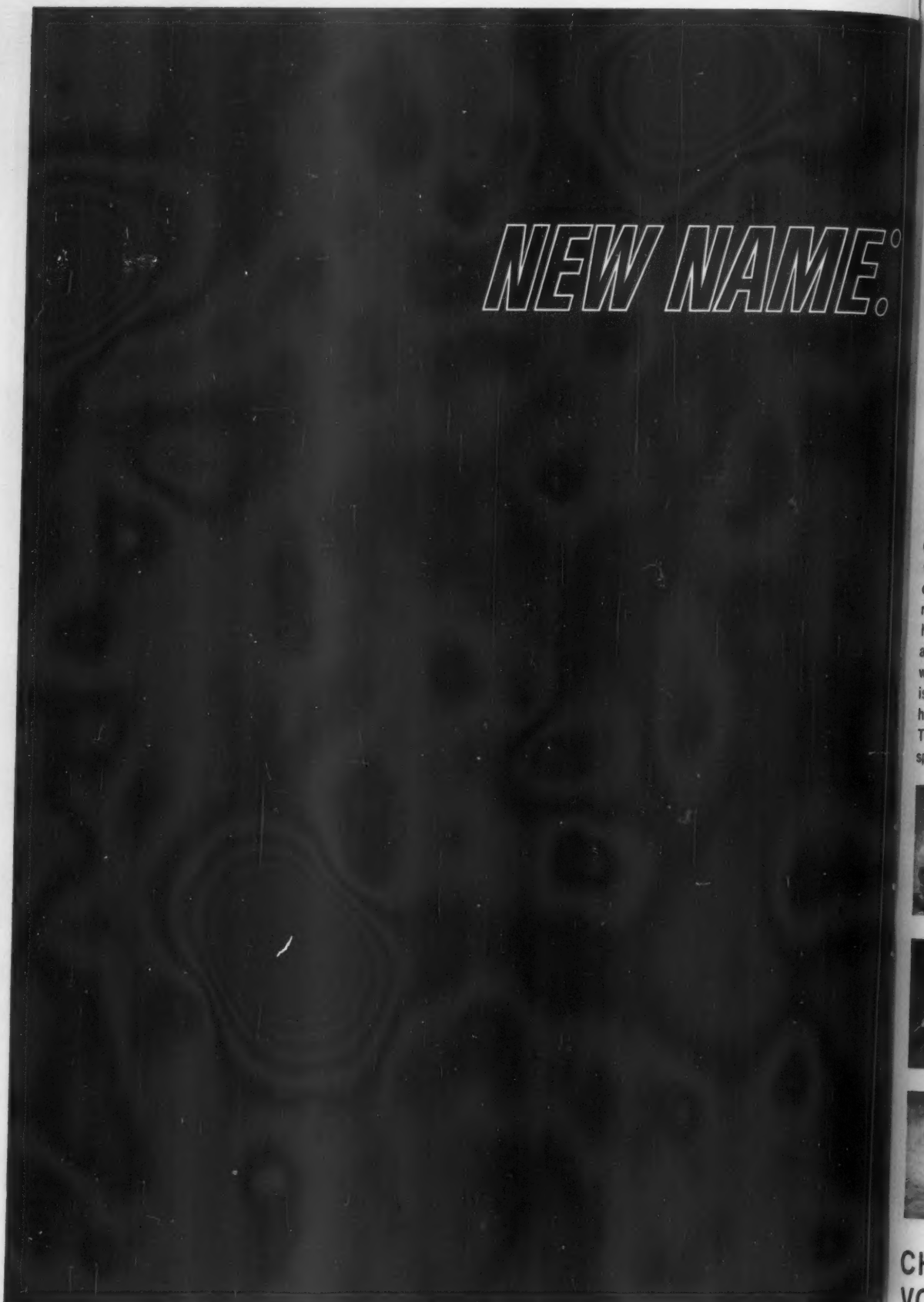
Concept Is Variable

Aerojet points out that its concept is not static. It can be varied for size of vehicles, functional capacity and mode of operation.

Another Aerojet concept, which could be used in conjunction with PROP or fitted into another system, would have



GRAPH shows future booster capability with new propulsion systems (AW Dec. 5, p. 38).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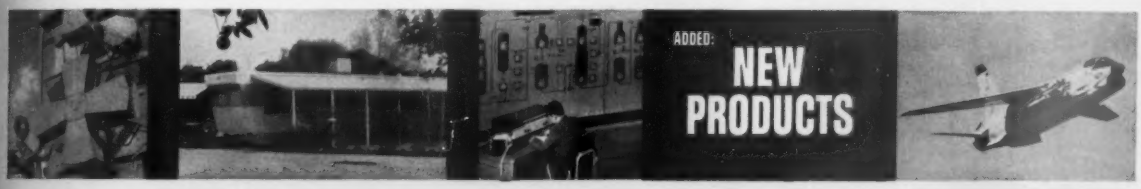

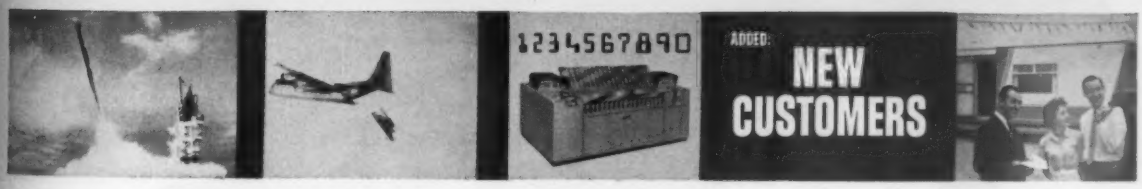

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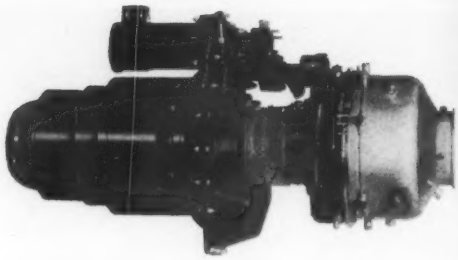

Solar gas turbine APU starts and supports Army's new YHC-1B jet helicopter

Solar's new Titan T-62T gas turbine APU enables the Army's YHC-1B *Chinook* to start anywhere without ground support equipment. It provides the power necessary to start the engines and to operate all hydraulic and electrical systems. The self-sufficient turbine develops up to 80 hp, is only 12½ in. in diameter by 25 in. long, and weighs 61 lb. Solar APU's may be equipped with an alternator, generator, hydraulic pump, pneumatic compressor or combinations of these units. For additional information write to Dept. H-188, Solar Aircraft Company, San Diego 12, Calif.

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the vehicle towed to sea from a seaside construction site.

This alternate system calls for a floodable sponson to be attached to the firing end of the vehicle. At the firing site, the sponson would be flooded at its farthest end, automatically erecting the launch vehicle to the vertical position for firing.

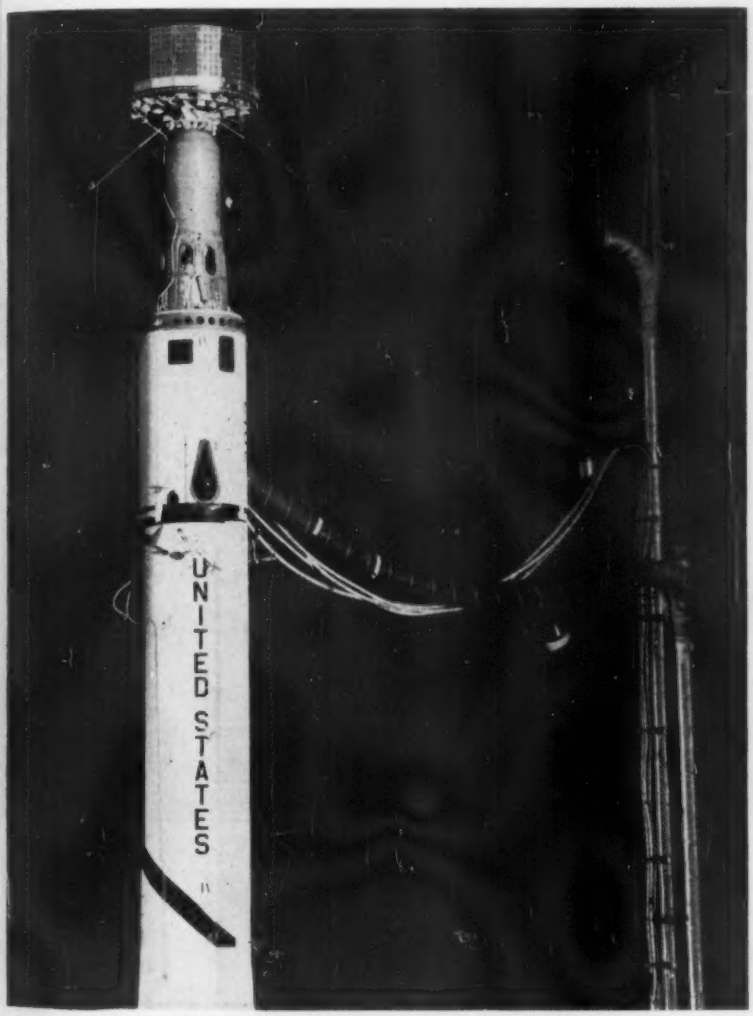
An extension of this system involves firing from the sea bottom in relatively shallow areas.

Martin Co. has studied independently a tanker concept for supplying remote or sea-based launching sites with propellants (AW Sept. 5, p. 68).

NASA, Air Force and the Navy all are careful to point out that the sea launch is still in the exploratory stage. They feel however, that with increasing size, weight and propulsion complexity, launchings may have to make use of the ocean areas. Specific system designs will have to wait for vehicle development, when their configurations and operating capabilities will be known.

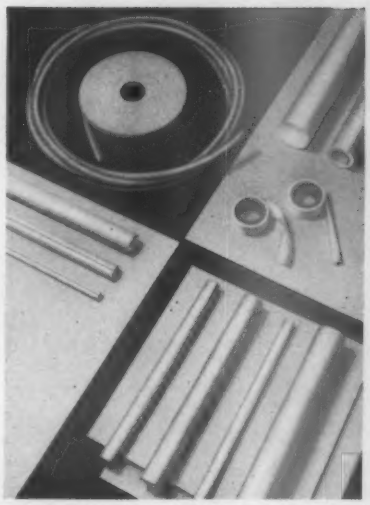
On missile bases, Air Force estimates that multiple launch sites hardened to 100 to 300 psi. would make any attempt to knock them out uneconomical. Current yardsticks for 10-megaton bursts show that 5 psi. structures would be destroyed at 15,000 yards from ground zero. Costs for hardening to 100 to 300 psi. have not been published. Some Air Force officials have even discussed hardening to 10,000 psi. These site hardening costs could be avoided by using the sea launch approach.

In launch aborts, the greatest cost is in reconstruction of the installation. This not only involves high cost but the loss of valuable use time of a specialized complex. These factors would be greatly diminished in sea launch operations.



Tiros II Satellite Atop Thor-Delta

Tiros II weather observation satellite, launched into orbit recently from Cape Canaveral, Fla. (AW Dec. 5, p. 28), is shown atop a Douglas Thor-Delta rocket launching vehicle before installation of the nose fairing.



Critical electrical parts in high-heat environments are typical applications for "Teflon"—a vital material which R/M specialists can best fabricate into the forms you need and deliver according to your schedule. New bondable R/M "Teflon" further increases applications in the aeronautics field.

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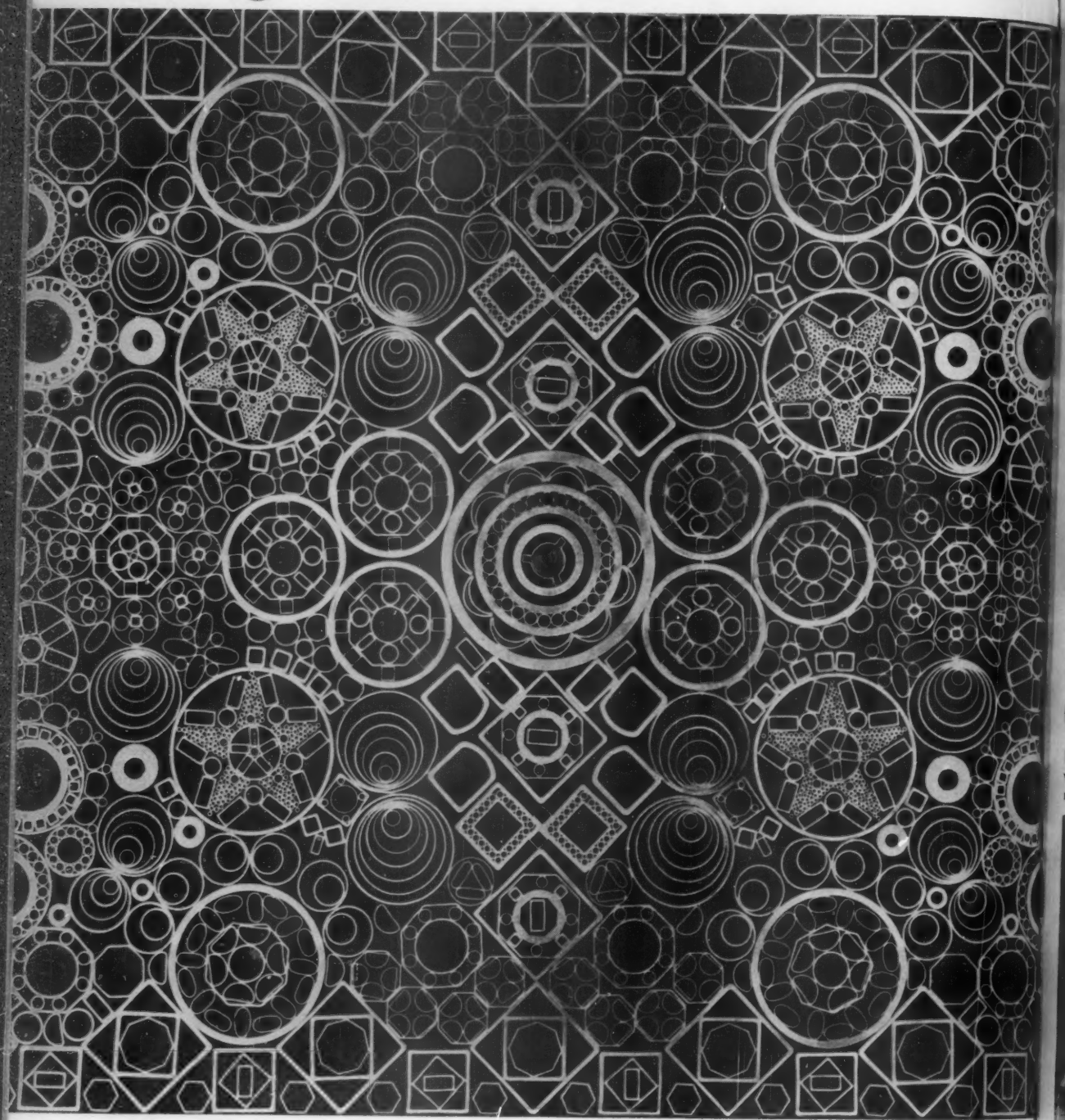

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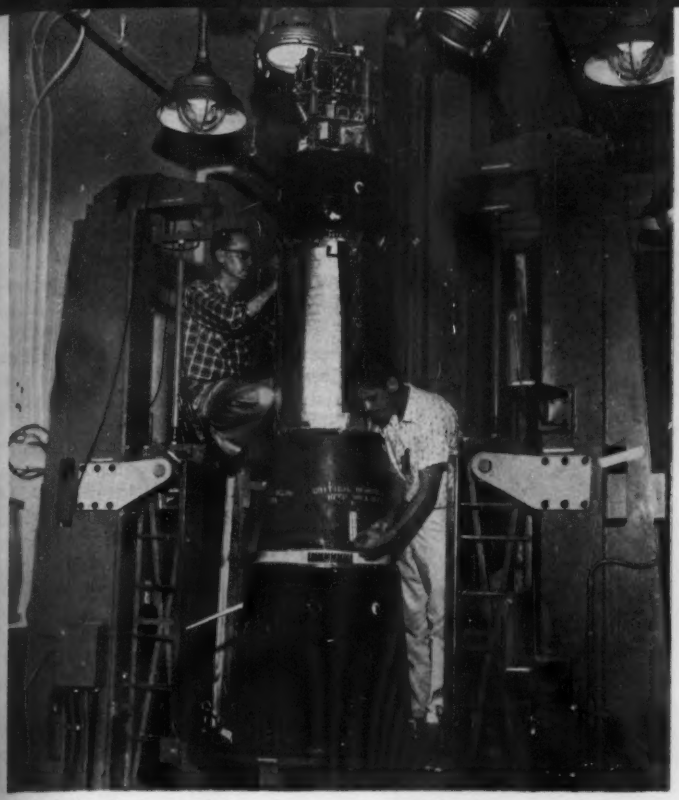
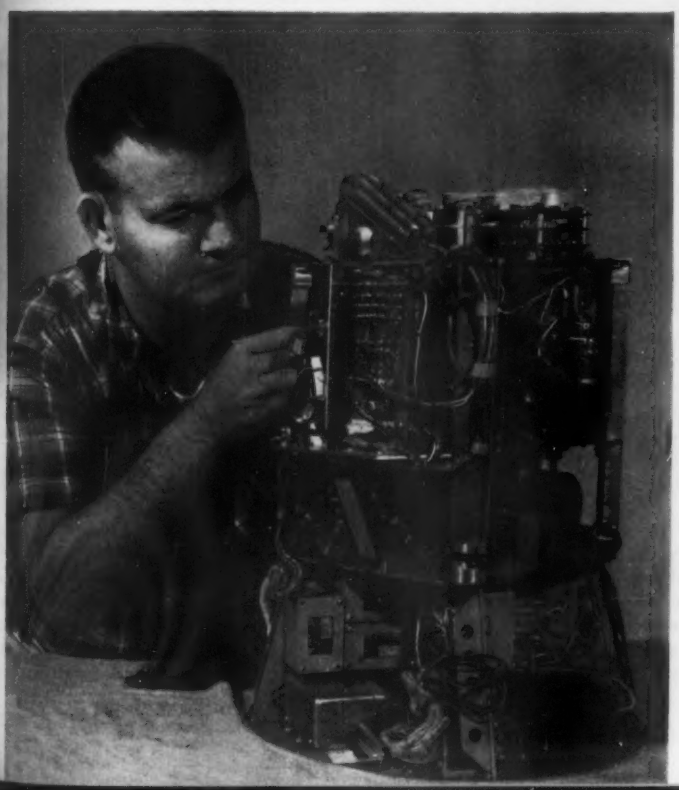


Payload, fourth stage and interstage connectors of the first successful four-stage Scout are assembled at NASA's Wallops Island, Va., station.

NASA Launches Four-Stage Scout On Developmental Test Flight

Instrumentation is installed on the payload section of the first successful Scout vehicle. Payload contained USAF radiation-measurement equipment and instruments to monitor flight performance of the fully-guided Scout.



First completely successful firing of the four-stage Scout vehicle carries a USAF payload on an 80-min. probe to 3,500-mi. altitude and range of 5,800 mi.

Assembled 72-ft. Scout vehicle is ready for launch at Wallops Station. Vehicle weighs 36,000 lb. and is largest all-solid-propellant vehicle launched by U.S.

NASA Programs Saturn Booster Recovery

New York—No attempt will be made to recover boosters in the initial Saturn test flights, but booster recovery is definitely scheduled later in the Saturn program, according to Dr. Wernher von Braun, director of the National Aeronautics and Space Administration's Marshall Space Flight Center.

NASA was planning to start a new series of 6-8 static tests of the 85-ft. Saturn at Marshall last week in a development program leading to the first test flight next summer.

Von Braun said that recovery will not be tried in the first tests in order to keep the tests as simple as possible. He said, however, that spent booster recovery will be the next major method to reduce space transportation payload costs per pound. Saturn will put one pound of payload into orbit for $500, compared with $1 million per pound for the first Vanguard, he said.

Recovery Technique

Recovery technique will involve use of a control system to orient the casing in a tail-down attitude as it re-enters the atmosphere. After re-entry, a conical drag-stabilization balloon will deploy.

Landing system consists of three cargo parachutes.

At 100-ft. altitude, solid propellant retrorockets will ignite to reduce landing velocity close to zero.

Spent booster will follow a ballistic trajectory into an estimated 5-mi. dispersal area, where a landing ship dock (LSD) will be stationed for retrieval.

New test series beginning at Huntsville, Ala., will use booster chambers approximating those of the flight vehicle.

Two tests of the clustered eight engines are planned for duration of less than 30 sec., and the rest will run 100 sec. or more.

Each engine will develop 165,000-lb. thrust initially, and the system will be developed so that ultimately each will develop 188,000-lb. thrust.

First Tests Successful

First series of eight captive tests was completed in June, and von Braun said they were "100% successful" in establishing the feasibility of clustering large liquid rocket engines.

Current series will use engine chambers with heavier shielding added to the tail section. Heat shield has been installed at the nozzle throat level, and a flame shield has been installed between the nozzles of the four inboard engines. Fire wall has been installed below the fuel and liquid oxygen tanks, and a lower shroud has been added to encase the engine down to the level of the flame.

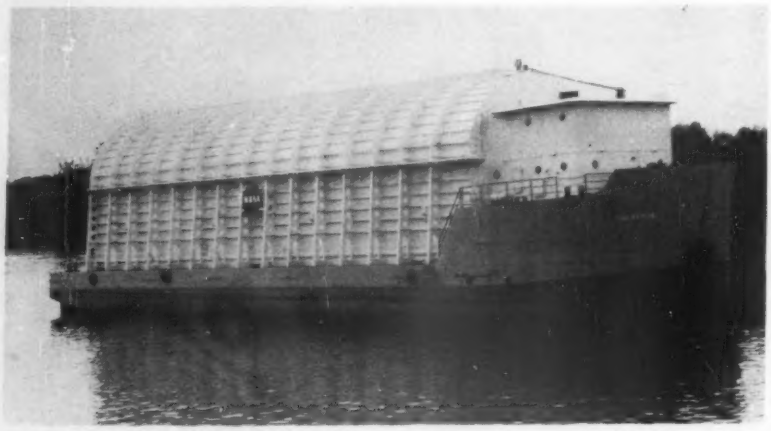
Test program is being run to determine general engine performance, using 900 data channels to record information on vibration, pressure, temperature, acoustical measurements and fuel consumption rates.

Sound Distribution

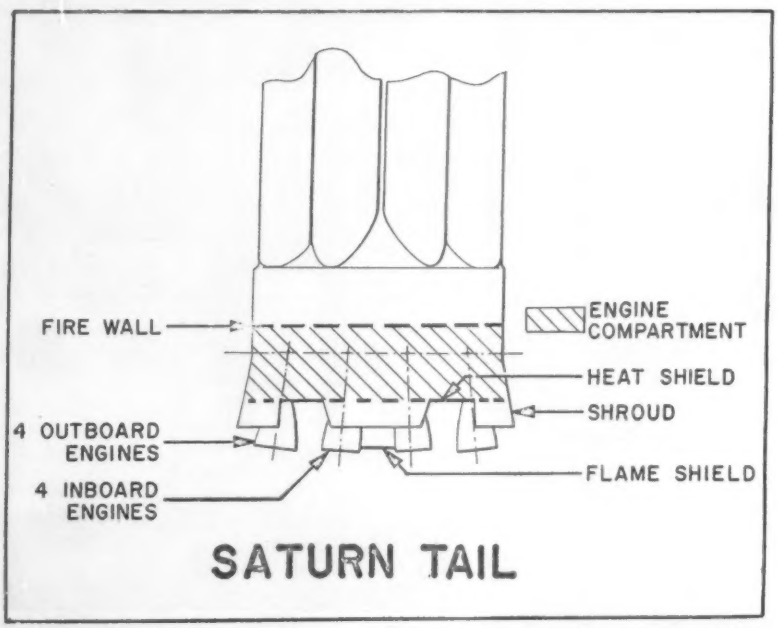
Measurements will be made on the booster, the test tower and in the adjoining area to determine sound distributions caused by addition of the lower shroud.

In other Saturn developments, Marshall is evaluating proposals for a study contract for automated test equipment for the booster stage, and Douglas Aircraft Co. has been awarded an $85,000 contract to study operational aspects of the second generation Saturn C-2 configuration.

Douglas study, due in eight months, will examine production, recovery and reconditioning, checkout, static test, transportation, launch site operations and facilities and flight evaluation.



PALAEMON, a 180-ft. long, 38-ft. wide barge that will transport NASA's Saturn heavy space booster to its launch site at Cape Canaveral next year for its first flight test, arrived last week at the Marshall Space Flight Center, Huntsville, Ala., after a 16-day trip from Houston, Tex. Built by the Todd Shipyards Corp. of Houston, the barge contains its own electrical power source, instrument room, kitchen, sleeping for 10 persons.



LOCATION of shielding to protect against radiated and conducted heat generated in Saturn captive tests is shown in this drawing of the tail section of the booster.

Ship Provides Precise Missile Tracking

Cape Canaveral, Fla.—Absolute measurements of missile trajectories down the Atlantic Missile Range will be provided by the newest USAF downrange vessel, Twin Falls Victory, using the missile's launch stand as the reference point for the tracking operation.

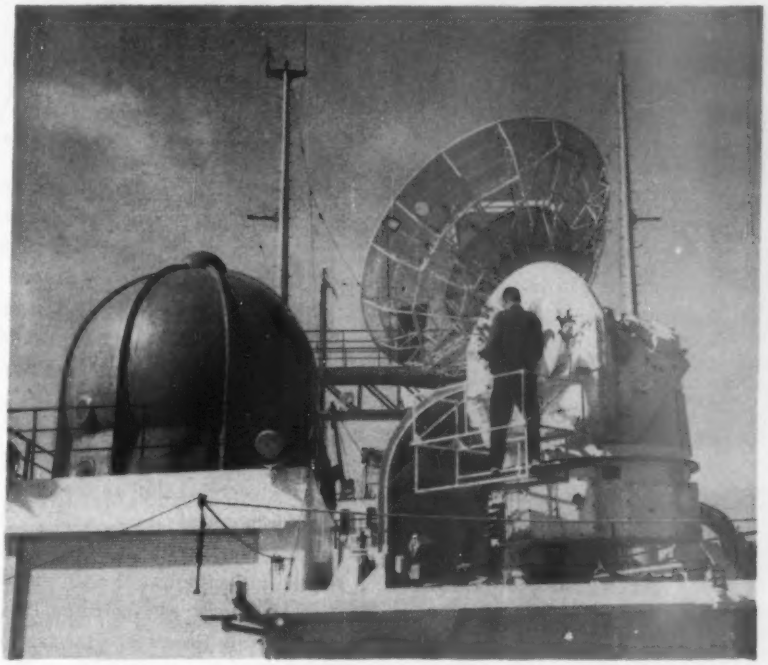
To perform precision tracking, Twin Falls is fitted with AN/FPS-16 (tracking) and SPN-8 (surveillance) radars, N7C inertial platform, Mark-19 gyro compass, UHF transmitting and receiving antennas and high-frequency LORAC (Long Range Accuracy) radio positioning equipment. The ship will begin operating by mid-1961 with flight tests of the Army's solid-fueled Pershing surface-to-surface missile. Range of the vessel will be about 500 mi., but this can be extended without difficulty when more downrange geographical points or additional LORAC sites are more precisely located for the ship to position itself.

Previously, only land-based tracking stations have made absolute (three-dimensional) measurements, within an error of 0.2 mils (20 ft. per 100,000 ft.). Twin falls is expected to begin operations within 1 mil and improve with time. Biggest advantage of the vessel is its ability to move into varying target areas and meet requirements of different programs. USAF also feels that quality of tracking data should improve and that the range safety problem should be considerably alleviated by programing more shots toward open seas.

LORAC sites, on which the Twin Falls will position itself, have been located by first-order coast and geodetic surveys. Two networks, one comprising sites at Jupiter, Fla., Grand Bahama Island and Carter Cay, a Bahama bank island, and the other including Carter Cay, Great Stirrup and Eleuthera, will lay down base lines developing hyperbolic patterns. Phasemeters aboard the vessel will read the shifts between lanes of the patterns and, from previously-computed relationships between lanes and longitude and latitude, the Twin Falls will be able to determine its position within 30 ft.

Radar operation of the Twin Falls consists of two modes—acquisition and tracking. Land-based stations will first pick up the missile's flight on their radars and transmit azimuth, elevation and range data to the ship through radio links. With this information precomputed trajectory tapes and knowing both its position and the position of the launch stand (also determined by first-order coast and geodetic survey), the FPS-16 will search until it locates the missile. Once located, the radar will lock on its tracking mode and the data fed into a computer.

TWIN FALLS VICTORY, newest USAF downrange vessel, will make absolute measurements of missile trajectories. Twin Falls, built in 1945, is 455-ft. long with a 62-ft. beam.



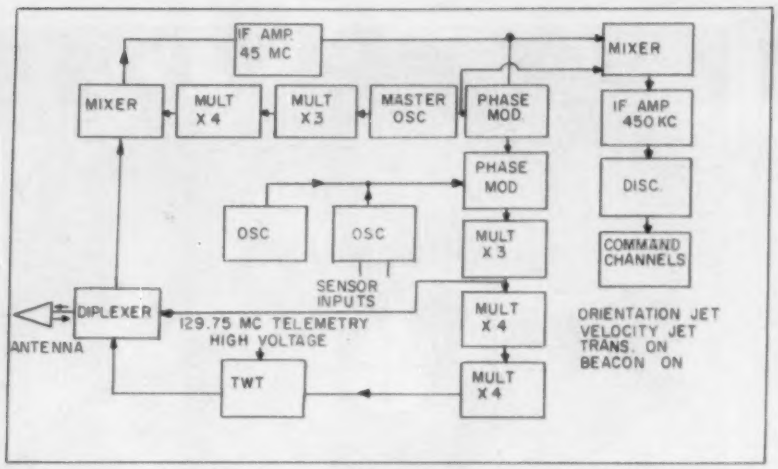
ENGINEER checks out precision tracking AN/FPS-16 radar aboard Twin Falls. Angular tracking data of the radar is corrected by stable inertial platform in room beneath pedestal.

The N7C inertial platform records the pitch, roll and yaw of the ship and the rigidly-mounted radar platform. This information is also fed into the computer, where data processing corrects radar angle data with angle data from the stable platform. Corrected information is then stored on magnetic tape.

SPN-8 surveillance radar is used for impact location and is similar to carrier-based GCA radar.

Corrected tracking data will be transmitted to overhead downrange aircraft on UHF transmitters and flown back to the Cape, eliminating the necessity of the ship's return to port.

Total cost of conversion, including all equipment described above, was $10



TRANSPONDER within Hughes communication satellite, shown in block diagram, can receive and retransmit up to 600 two-wire or 300 four-wire messages across continental distances. Entire avionics package weighs 6½ lb.; it will also telemeter data, receive ground-based commands and handle guidance signals.

Blue Scout), Hughes scientists have settled on Jarvis Island, two square miles of U. S. Department-of-Interior-administered property situated slightly below the equator, about 1,300 mi. south of Honolulu. Besides the attractiveness of a deserted location for an equatorial launch, the island also offers hundreds of miles of down-range (eastward) open-sea areas. Launched from this spot, the payload, were it to attain stationary orbit, would be located at 51.9 deg. west longitude, Rosen says.

Successful orbiting over the equator at this point would place the satellite over Brazil above an area near the coastal city of Belem. A locus of all geographical points within communication distance from this single satellite encompasses most of North and South America, Western Europe and Africa on an arc from Benghazi to Capetown. If this plan were followed, Hughes is thinking initially of two fixed-antenna ground stations, one in the Los Angeles area, the second probably in France or Belgium.

Fifth Stage Velocity

The payload would be launched into an equatorial plane, injected into a transfer ellipse after burnout of a fifth stage rocket (a state-of-the- art modification or addition to the Scout four-stage rocket) and, after coasting to apogee, would be injected into a nominally synchronous orbit. The fifth stage supplies additional velocity and contains the velocity cutoff mechanism.

Launch sequence for the 150-lb. gross payload (including fifth and sixth stage, or apogee, rockets) was outlined by Rosen as follows: Vehicle is launched eastward from Jarvis Island. After third-stage burnout it spins since it no longer is attitude-controlled as are the first stages.

Fourth stage and payload are spin stabilized.

A single-plane doppler interferometer guidance system, located on Jarvis, measures the vehicle's altitude and velocity. At the appropriate moment, a ground command cuts off thrust and the fifth stage separates from the payload.

The antenna erects during fifth-stage separation and the payload enters a transfer ellipse. It coasts for 5 hr. 16 min. until reaching apogee where the sixth stage, which supplies additional velocity for injection into a nominally synchronous orbit, fires on command. In an accompanying cross sectional view of the Scout payload, the apogee rocket appears to be in a reverse position. The velocity vector of the payload, however, undergoes a 180 deg. change from perigee to apogee to properly orient it for final sixth-stage burst.

In nominally synchronous orbit, the payload spins about its cylindrical axis, which is in the equatorial plane. An orientation or torquing gas jet, whose thrust axis is parallel to the spin axis of the satellite but displaced from the payload's center of gravity, then precesses the satellite 90 deg. to make its spin axis parallel to the earth's. Operating under ground command in the pulse mode, the jet torques the payload over 90 deg. to place it in the proper plane.

Subsequently, it can be operated in a continuous wave mode to produce thrust perpendicular to the equatorial plane to correct for inclination errors.

Proper phasing of ground-command pulses for jets, is provided by the two clam-shaped sun sensors.

The plane of sensitivity of one sensor passes through the satellite's spin axis and determines spin phase, while the plane of sensitivity of the second sensor is tipped 35 deg. with respect to the first and is used to determine angle of the sun relative to spin axis of the satellite. With this spin angle information, telemetered from payload back to ground guidance station, a synchronous controller generates commands for the orientation and velocity jets.

A second control jet, whose thrust axis passes through the payload's center of gravity and is normal to the spin axis, provides velocity correction. On command, this velocity jet can increase orbiting velocity. The torquer jet, operating in its cw mode, corrects for inclination changes.

Satellite Lifetime

After a stationary orbit is achieved, jet control can be maintained for limited periods. Velocity capability of the two nitrogen tanks is about 250 fps., Rosen estimates. Lifetime of the satellite is limited to about one year by solar cell degradation and gradual inclination build-up of 1 deg. a year which eventually places payload out of control.

Rosen calculates that satellite launch has 100% probability of achieving synchronism, 50% probability of being stationary.

Intercontinental communications would be possible using only a single stationary satellite backed up by one spare in orbit. Any number of ground terminals could be tied in. The spare satellite could relay TV and, in the event of failure in the main satellite, the spare could switch over to telegraph/telephone relay.

The operating prototype designed for Thor-Delta launch differs in several

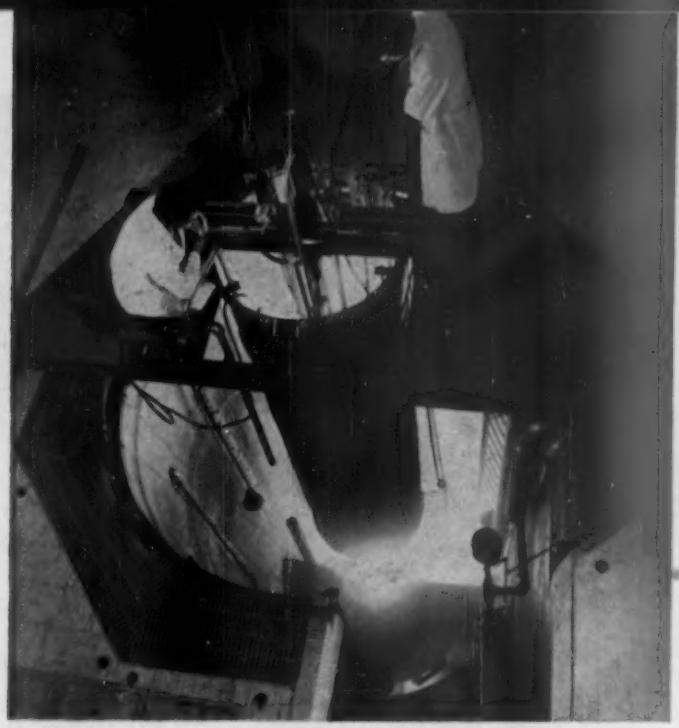
Man-in-Space Contracts

Edwards AFB, Calif.—Contract for a 12-channel biological telemetry system (AW Nov. 21, p. 23) capable of transmitting a pilot's physiological responses during flights of vehicles like the X-15 and Dyna-Soar, was awarded last week to Hughes Aircraft Co., Culver City, Calif. Value of the award was placed at $78,698.

This is the second in a series of four awards to be made by the Air Force Flight Test Center for instrumenting man-in-space environments.

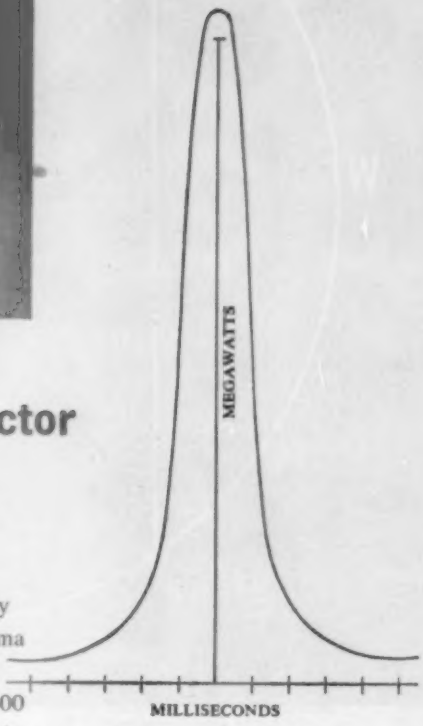
A $47,100 contract for a pressure gas sensor is about to be awarded and a contract for a blood pressure measuring device, fourth contract in this series is expected in the near future.

First contract in the series went to Spacelabs, Inc., Van Nuys, Calif., late in October. Under this $23,579 contract, Spacelabs will build a breathing study device to measure man's respiration rate and depth in a full pressure suit.



TRIGA Mark-F now in operation at General Atomic.

The TRIGA Mark-F Pulsing Reactor



General Atomic Division of General Dynamics Corporation is pleased to announce a new addition to its TRIGA family of reactors—the TRIGA Mark-F Pulsing Reactor.

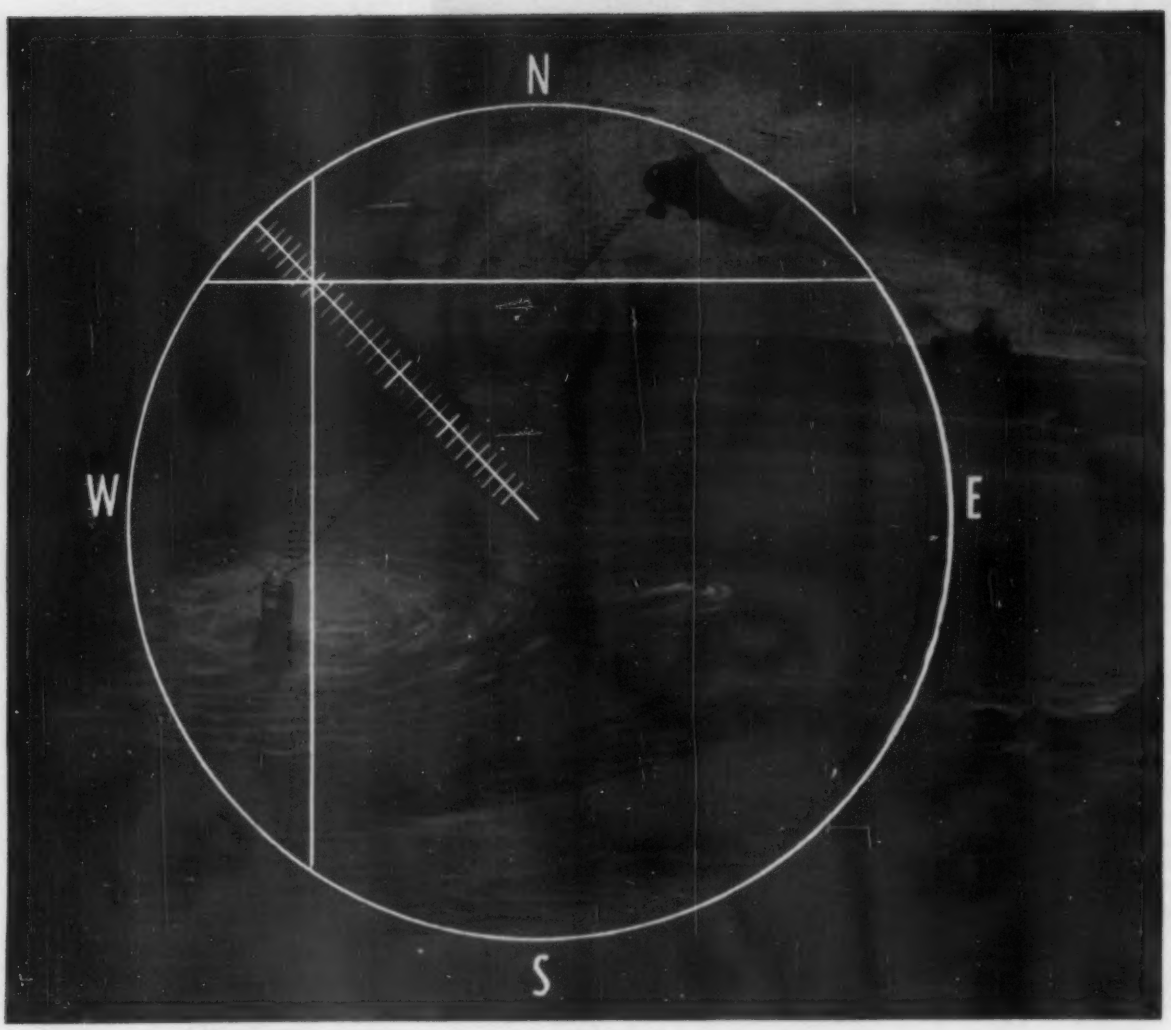
The TRIGA Mark-F, developed by General Atomic, is especially designed to yield short reproducible pulses of neutrons and gamma rays for use in nuclear effects research and testing. It is capable of being pulsed repetitively to peak power levels of over 2,000,000 kilowatts with half-maximum pulse widths of 10 msec, owing to the inherent characteristics of the TRIGA reactor's unique uranium-zirconium hydride fuel elements. During pulsed operation, a maximum flux of 6×10^{16} neutrons/cm^2-sec. can be achieved. The Mark-F design permits variation of neutron to gamma dose ratios by a factor of ten and provides for a large, easily accessible exposure window immediately adjacent to the core.

A prototype of the TRIGA Mark-F was placed in operation the summer of 1960, and construction of two such reactors will be completed in 1961 for the United States Government, including one for the U.S. Army's Diamond Ordnance Fuze Laboratories. Other versions of the TRIGA include the TRIGA Mark I and Mark II reactors—for training, research and isotope production—which are now in use, or soon will be, on five of the six continents.

For more information on the TRIGA Mark-F, write to:
TRIGA Applications Group, General Atomic,
P.O. Box 608, San Diego 12, California

Openings for electronic and electrical engineers.
Write: Manager of Personnel, General Atomic.

GENERAL DYNAMICS / GENERAL ATOMIC DIVISION



Reporter on the prowl
Norden's Doppler Wind-Distance Computer

In anti-submarine warfare operations, the Navy's Air Arm acts as an aerial eye transmitting target information to surface attack vessels. Norden's compact, lightweight Doppler wind-distance computer presents the pilots with a continuous display of wind velocity and provides accurate information on distance travelled. In the absence of Doppler return, the wind-distance computer continues to provide distance data, based on air speed and computed wind information.

The Norden Doppler wind-distance computer project, successfully developed for the Naval Air Development Center at Johnsville, Pennsylvania, testifies to the company's capability in the airborne analog computer field. And every Norden achievement in the area of advanced electronics is another step toward extending man's capabilities.

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respects from the Scout version. Thor Delta version is heavier, employs four toroidal steel tanks filled with compressed nitrogen required by the control jets. It weighs 118 lb., including what for Thor-Delta would be the fourth stage, the apogee rocket. After apogee-rocket burnout, and separation of rocket case, weight in orbit is 52 lb. Gross weight of the Scout payload, including five-stage rocket and six-stage apogee rocket is 150 lb. After separation of the fifth stage, and burnout of the apogee rocket (the apogee rocket itself does not separate from the satellite in this version), the Scout-boosted satellite weighs 32 lb. Part of the weight reduction in the Scout version is made possible by less demand on jet supply. Supply for this version is contained in two titanium toroidal tanks.

Guidance System

The satellite's guidance system, a single-plane doppler interferometer system, would be situated on Jarvis Island. It consists of an 800 w. UHF guidance and command transmitter, a nearby S-band receiver, both equipments on gun mounts, and an angle tracking S-band receiver displaced about two miles on a tracking pedestal to form an interferometer.

The two receivers, each of which has a 10-ft. dish, measure range rate, range, elevation angle and elevation angle rate.

At the first receiver an analog computer solves necessary linear equations and computes cutoff time.

The transmitter signals for thrust cutoff, commands apogee rocket firing, orientation and velocity jet operation, and satellite transmitter turn-on and turn-off during transfer ellipse and eclipses. Total cost of instrumenting the island, including preparation of a 5,000 ft. C-130 runway on the island, would be less than the range cost for firing a single large booster from Cape Canaveral.

Transporting personnel to and maintaining them at Jarvis would increase this considerably, however.

Project Leaders

A number of engineers and scientists at Hughes pooled their talents in analyzing, designing and engineering the satellite project. Among them were Tom Hudspeth, responsible for the avionic design, Don Williams, orientation method and dynamic analysis of the entire system, Ralph Colbert, supervision of the structural design and integration of units, and Ed Marriott, a project manager for mechanical and thermal design of the payload.

Besides completing the Thor-Delta payload, Hughes has finished the transmitter and analog computer and has breadboarded the receiver.

Air Force Research Grants

Washington—Contract awards and grants for basic scientific research in universities, nonprofit institutions and industrial laboratories made by Air Force Office of Scientific Research since Aug. 1 total $3,639,271. Contracts and grants are as follows:

Contractor	Date Work Started	Short Title	Estimate of Cost
Behavioral Sciences			
Ohio State Univ., Columbus, Ohio	Aug., 1959	Personality Factors in Motivation	$28,609
Univ. of Georgia, Athens, Ga.	Nov., 1959	Technological Changes Impact on Careers	50,093
Mass. Mental Health Ctr., Boston, Mass.	Aug., 1959	Hypnosis as a Contro	38,349
Ohio State Univ., Columbus, Ohio	Apr., 1958	Situational Variables	65,400
Biological Sciences			
Univ. of Calif., Berkeley, Calif.	May, 1959	Brain Tolerance to Space Environment	26,338
RIAS Division, Baltimore, Md.	Aug., 1960	Photosynthesis	27,193
Chemical Sciences			
Columbia Univ., New York, N.Y.	Aug., 1960	Microwave Spectroscopy	41,074
Univ. of Calif., Berkeley, Calif.	Feb., 1960	Chemical Effects of Radiation	110,000
Purdue Res. Found., Lafayette, Ind.	June, 1960	Properties of Silyl Radicals	37,473
Univ. of Wash., Seattle, Wash.	July, 1960	Boron and Silicon Compounds	44,000
Wash. State Univ., Pullman, Wash.	Feb., 1959	Pyrolysis of Esters	38,998
Univ. of Calif., Berkeley, Calif.	July, 1960	Molecular Spectroscopy	54,002
Rensselaer Poly. Inst., Troy, N.Y.	June, 1960	Surface-Catalyzed Excitation of Atoms	114,700
Southern Research Inst., Birmingham, Ala.	Oct., 1958	Diffusion of Iron	41,220
Northwestern Univ., Evanston, Ill.	June, 1960	Catalysis in Liquids	26,000
Kent State Univ., Kent, Ohio	Mar., 1959	Electrolytes in Acetic Acid	12,392
Tufts, Univ., Medford, Mass.	Dec., 1957	Intermediates in Ozonation	14,860
Univ. of N. Hamp., Durham, N. Hamp.	Jan., 1958	Organoboron Chemistry	14,400
Johns Hopkins Univ., Baltimore, Md.	May, 1956	Microcatalytic Techniques	12,063
Northwestern Univ., Evanston, Ill.	Jan., 1958	Platinum Metal Compounds	14,550
Univ. of Oregon, Eugene, Oreg.	July, 1958	Surface Chemistry of Nonpolar Molecules	15,730
Cornell Univ., Ithaca, N.Y.	July, 1960	Diels-Alder Reaction	22,916
Univ. of Kansas, Lawrence, Kan.	July, 1960	Transport Processes (grant)	43,460
Johns Hopkins Univ., Baltimore, Md.	June, 1958	Free Radicals & Reactive Molecules	28,558
Univ. of Minn., Minneapolis, Minn.	Oct., 1958	Non-aqueous Polarography & Amperometry	25,820
Princeton Univ., Princeton, N.J.	June, 1958	Photonemetric Titrations	56,400
Poly. Inst. of Brooklyn, N.Y.	Jan., 1958	Adsorption of High Polymers	17,834
Indiana Univ., Bloomington, Ind.	Jan., 1958	Electrochemistry of Fused Salts	15,212
Poly. Inst. of Brooklyn, N.Y.	Dec., 1957	Photochemical Reactions	24,565
Mathematical Sciences			
Univ. of N. C., Chapel Hill, N.C.	June, 1960	Linear Mixed Models	35,520
Inst. for Adv. Study, Princeton, N.J.	June, 1957	Advanced Mathematics	46,500
Carnegie Inst. of Tech., Pittsburgh, Pa.	Mar., 1960	Conformal & Variational Methods	56,895
Mechanics			
N. Amer. Aviation, Downey, Calif.	June, 1957	Laminar Boundry Layer Stability	62,662
Cornell Aero. Lab., Buffalo, N.Y.	Aug., 1960	High-Temperature Phenomena	79,994
Univ. of Minn., Minneapolis, Minn.	Dec., 1958	Mass Transfer Cooling	40,000
Univ. of Md., College Park, Md.	Mar., 1959	Boundry Layer Instability	41,300
Stanford Univ., Stanford, Calif.	Apr., 1957	Thermal Effects in Aircraft Structures	82,863
Cornell Univ., Ithaca, N.Y.	Nov., 1958	High-Speed Aerodynamics	74,588
Martin Co., Baltimore, Md.	Aug., 1960	Vacuum Environment & Materials	48,714
General Dynamics, San Diego, Calif.	Jan., 1958	Hydrogen-oxygen Interactions	83,403
Poly. Inst. of Brooklyn, N.Y.	Apr., 1957	Hypersonic & Low-Density Flow	243,000
Poly. Inst. of Brooklyn, N.Y.	May, 1958	Vibrations of Cylindrical Shells	26,000
Stanford Univ., Stanford, Calif.	Mar., 1957	Irreversible Processes	37,105
Univ. of Calif., Berkeley, Calif.	Aug., 1958	Low-Density Wind Tunnel	150,000
Cornell Aero. Lab., Buffalo, N.Y.	Oct., 1959	High-Temperature Gas Flows	49,809
Cornell Aero. Lab., Buffalo, N.Y.	Oct., 1959	Nonequilibrium Flows	51,688
Cornell Aero. Lab., Buffalo, N.Y.	Oct., 1959	Molecular Interactions	99,968
Univ. of Minn., Minneapolis, Minn.	Feb., 1957	Heat Transfer at Hypersonic Speeds	40,000
Mass. Inst. of Tech., Cambridge, Mass.	June, 1960	Unsteady Gasdynamics in Flight Vehicles	40,750
Vitro Laboratories, West Orange, N.J.	July, 1958	High-Intensity Arc Plasma	42,070
Midwest Rsch. Inst., Kansas City, Mo.	Feb., 1958	External Force on Panel Flutter	37,850
Poly. Inst. of Brooklyn, N.Y.	Apr., 1958	Problems of Hypersonic Flow	125,020
Univ. of Toronto, Toronto, Canada	Dec., 1959	Magnetogasdynamics	9,693
Martin Co., Baltimore, Md.	June, 1960	Nonlinear Mechanics Symposium	9,000
Nuclear Physics			
Stanford Univ., Stanford, Calif.	Feb., 1958	High-Energy Electrons Scattering, etc.	150,000
Physics			
Northwestern Univ., Evanston, Ill.	July, 1960	Stellar Motion & Atmospheric Scintillation	43,823
New York Univ., New York, N.Y.	Jan., 1959	Control Systems	48,072
Stevens Inst., Hoboken, N.J.	Jan., 1958	Photon Spectroscopy	27,276
Columbia Univ., New York, N.Y.	Mar., 1959	Radio Astronomy	29,000
New York Univ., New York, N.Y.	Aug., 1957	Low-Frequency Absorption Spectra	15,076
St. John's Univ., Jamaica, N.Y.	July, 1960	Electron Collisions (grant)	29,900
Univ. of Minn., Minneapolis, Minn.	Feb., 1958	Gaseous Electronics	34,300
Columbia, Univ., New York, N.Y.	Sept., 1958	Infrared MASER	65,140
Columbia, Univ., New York, N.Y.	July, 1960	Radioactive Atoms	38,000
Yeshiva Univ., New York, N.Y.	Sept., 1959	Transport Properties	34,045
Princeton Univ., Princeton, N.J.	Dec., 1957	Stellar Evolution	6,336
Univ. of N. Hamp., Durham, N. Hamp.	May, 1959	Gaseous Plasmas and Solids	19,840
Propulsion			
Litton Industries, Beverly Hills, Calif.	Sept., 1959	Electromagnetic Plasma Accelerator	177,641
Princeton Univ., Princeton, N.J.	Mar., 1958	Ignition of Solid Propellants	53,000
Solid State Sciences			
Univ. of Colorado, Boulder, Colo.	Feb., 1959	Paramagnetic Impurities in Crystals	39,022
Univ. of Maryland, College Park, Md.	Mar., 1958	Solid-State Theory	38,016
Brown University, Providence, R.I.	July, 1958	Recrystallization	28,839
Univ. of Calif., Berkeley, Calif.	Aug., 1956	Stresses in Ceramic Bodies	33,400

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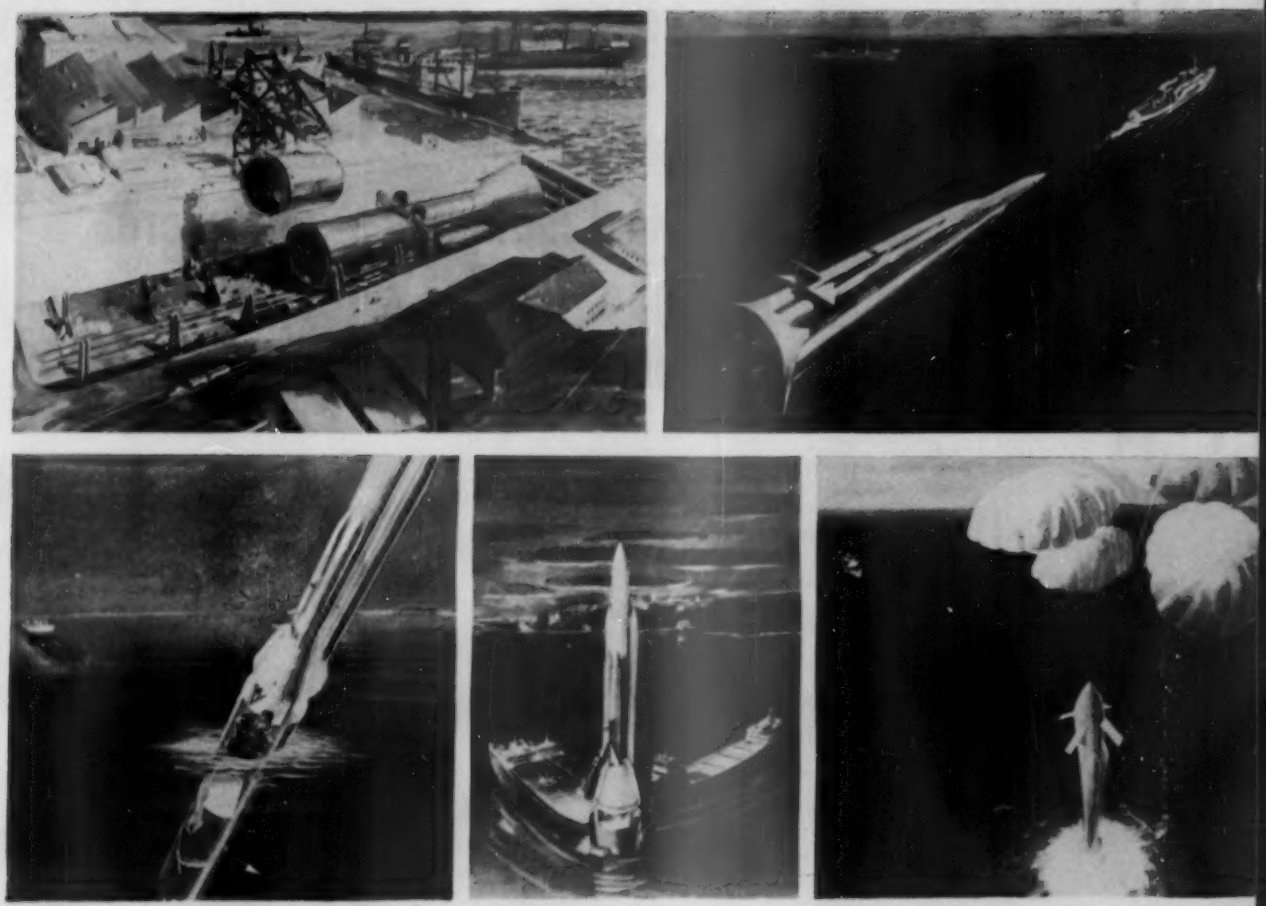

CONSTRUCTION of the three stages for a sea-launched space vehicle (top, left) takes place in drydock facilities. Drawing at top right shows booster and space vehicle being towed to the sea launch area. The booster and space vehicle are erected to launch position (below, left) by allowing sea water to flow into a section of the launching pontoon; arrow shows motion of erection. At center, the tender is floated into position. Drawing at right shows use of parachutes and retrorockets for recovery.

Sea Launch Studied for Space Vehicles

By Larry Booda

Washington—Interest in moving launch operations to sea is growing in military and civilian space organizations as the size of planned space vehicle boosters increases.

Air Force, Navy and National Aeronautics and Space Administration are considering the feasibility of establishing sea launch facilities for large boosters, and the concept conceivably could be extended to missiles. Economy and safety are the major gains involved in shifting to this new space launch technique.

Several companies have conducted sea launch studies, both on their own and with government funds. Some have worked alone, and others have teamed with shipbuilding firms to tap their experience. Proposals cover a variety of launch bases, including ships; ocean-going, partly-submerged floating platforms; towers anchored to the sea floor; floating booster-vehicle-pontoon combinations which can be erected after being towed to sea, and systems for launching from the sea floor.

These proposed systems could provide sea launch bases for:

- **Vertical probes.** They could be fired from a variety of locations around the world without the danger of damage as they fell back to earth.
- **Low orbit tactical** reconnaissance and attack satellites. They could be launched into any 100-200 mi. orbit without the dog-leg capability required with flights from fixed land bases.
- **Large tactical missiles,** such as Thor, Atlas, Titan and Minuteman. Sea launch would offer them mobility and concealment.
- **Large space boosters.** The new generation of chemically-powered boosters, such as Saturn and Nova, could be launched without the considerable expense of building new land installations.
- **Nuclear rockets.** Rover and other nuclear-powered rockets could be launched without radiation hazards to populated land areas.

Air Force expects to move development of sea launch systems beyond the study phase soon. With a requirement already established for an 800,000-lb. thrust booster under Project Phoenix (AW Dec. 5, p. 26), Air Force Ballistic Missile Division is interested in the mobility the sea launch concept offers with such a large space booster. USAF also is considering sea launch for the Csar communications satellite, which will be in a 24-hr. equatorial orbit.

Rand Corp. has had sea launch studies done for USAF by Wald Research, Inc., and the DeLong Corp. Thompson Ramo Wooldridge has proposed an offshore towable platform.

With its large vehicle programs not yet firm, NASA is interested in the sea

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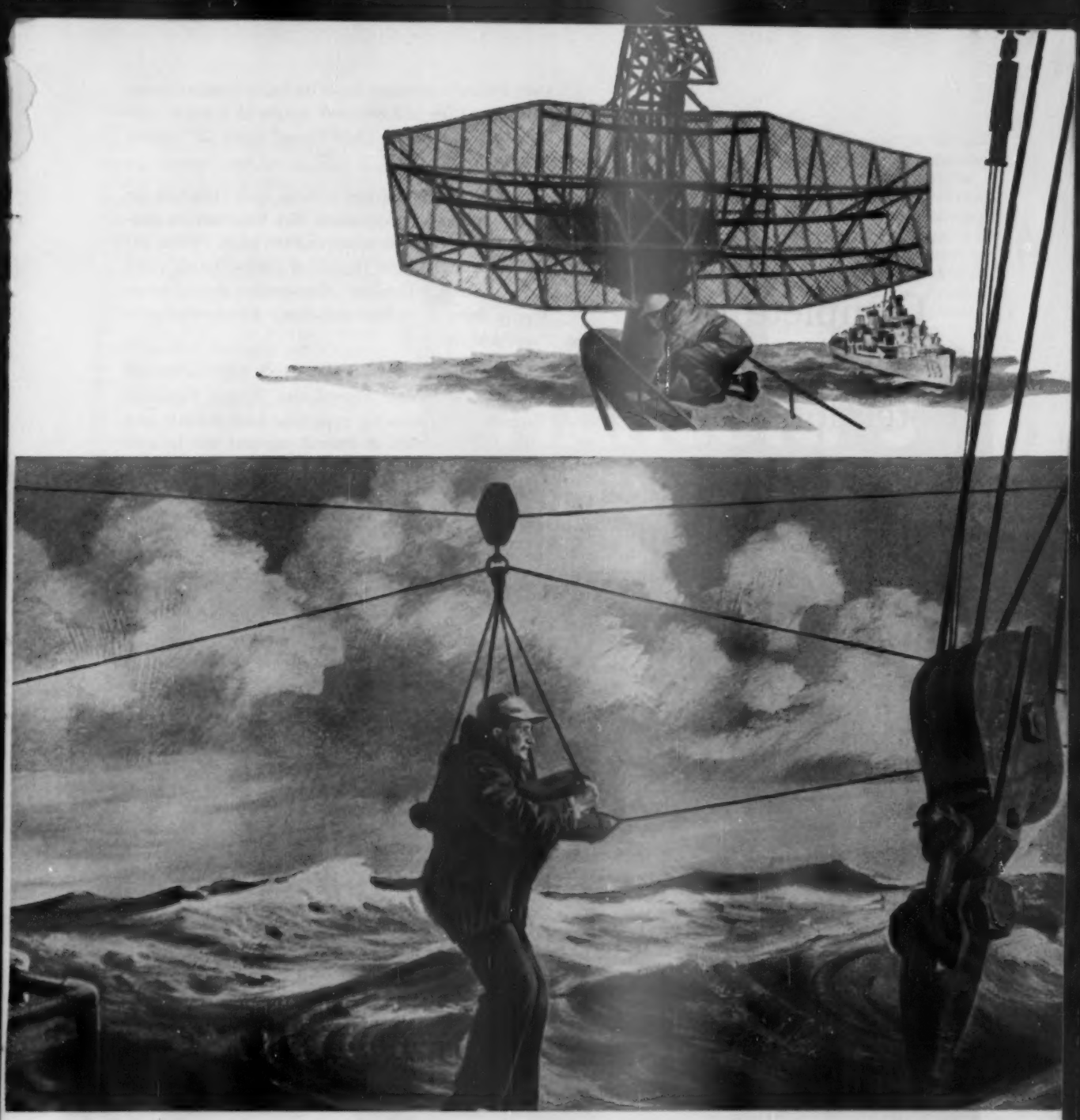

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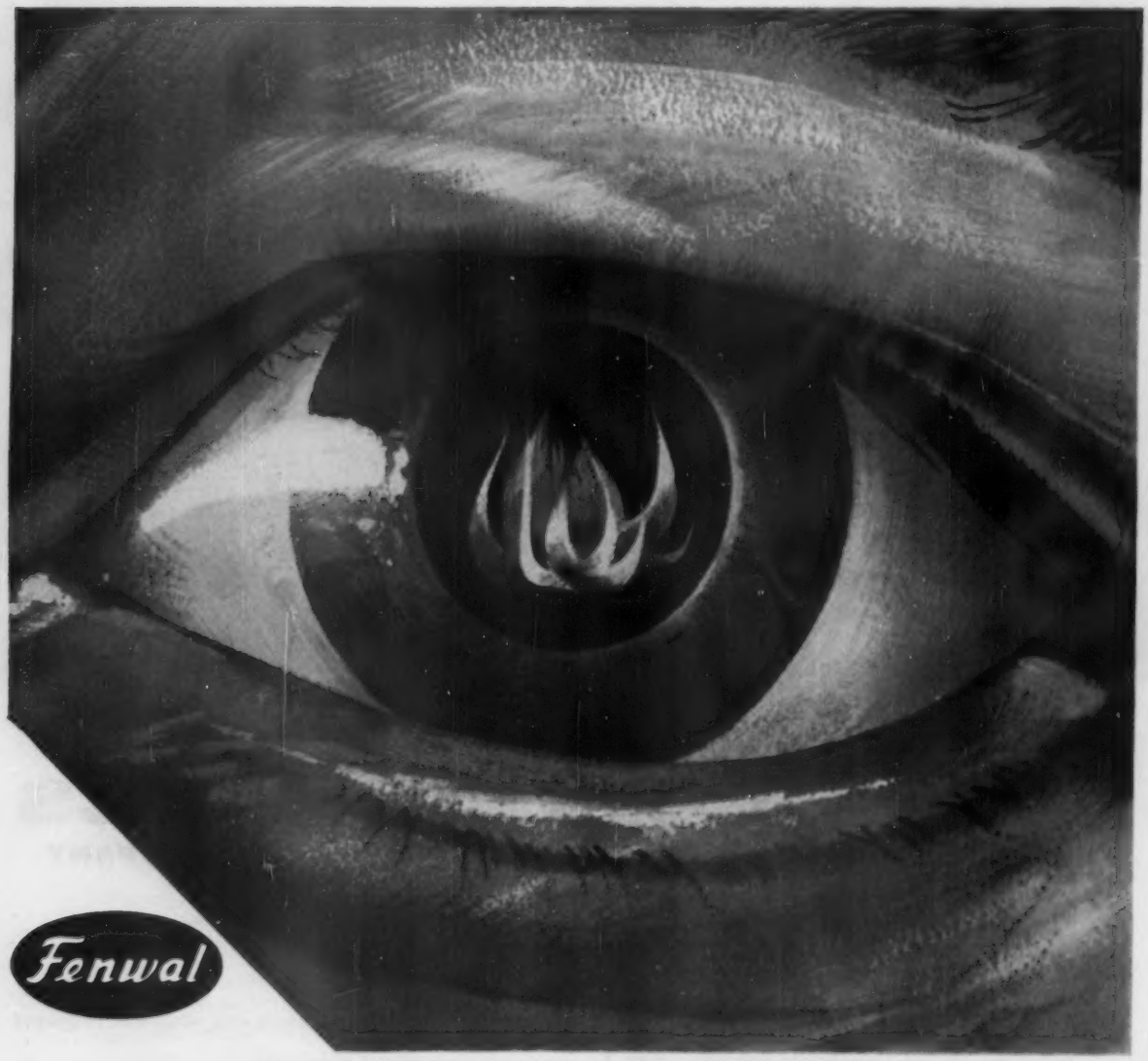

Fenwal

launch concept but has not generated any specific requirements. The agency's Nova vehicle will be powered by a cluster of large chemical boosters or a nuclear propulsion system, and NASA does not expect to produce a launch base requirement until it decides what kind of engines will power Nova.

Presentations of studies have been made to NASA by Cal-Val Engineering, teamed with Harbor Boat Building Co., Daniel, Mann, Johnson and Mendenhall (AW Sept. 12, p. 122), Kaiser Steel, American Machine and Foundry, and Aerojet-General teamed with Todd Shipyards.

Numerous advantages for launching at sea have been offered. Principal one is economy, since land installations are becoming more complex and expensive. Another is safety in case of failures by large chemical rockets and, later, nuclear-powered rockets.

For equatorial orbits, sea launch would permit the use of simpler guidance systems. If a vehicle is launched from Cape Canaveral, Fla. or Vandenberg AFB, Calif., a dog-leg would have to be added to the launching flight path to change the flight plane from one passing through the launch site to the plane of the equator.

Cost Estimates

Various estimates of the additional cost of dog-leg launches have been made, but the minimum estimate is 45-50%. Other estimates run three to five times the cost of the simpler guidance. Equatorial launch also could be made from a sea base without the expense of establishing a new land base on the equator.

In firing high-thrust powerplants, one high cost factor is the construction and operation of blast deflectors. In static testing, millions of gallons of water must be used for cooling. Water cooled deflectors and towers would be eliminated in sea testing and launching.

With military systems, the Navy advances the argument that mobility and secrecy are offered at sea for launching missiles and military satellites. Land sites, easily pinpointed by an enemy, would have to be considerably hardened for similar protection.

The coming of larger boosters brings a requirement for novel ways of constructing and handling them. Mobility will be reduced as the boosters become too large to be built at the manufacturer's plant and hauled to test and launch sites.

One answer to this problem is to assemble the booster at its launch site. Another is to build it near water so its size is not limited by road and rail facilities and it can be loaded directly on ships to be hauled to a sea launch site. Ships could accommodate the whole vehicle, or at least larger compo-

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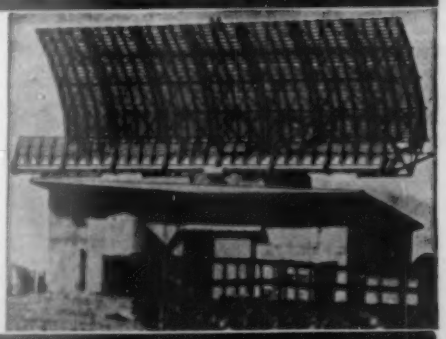

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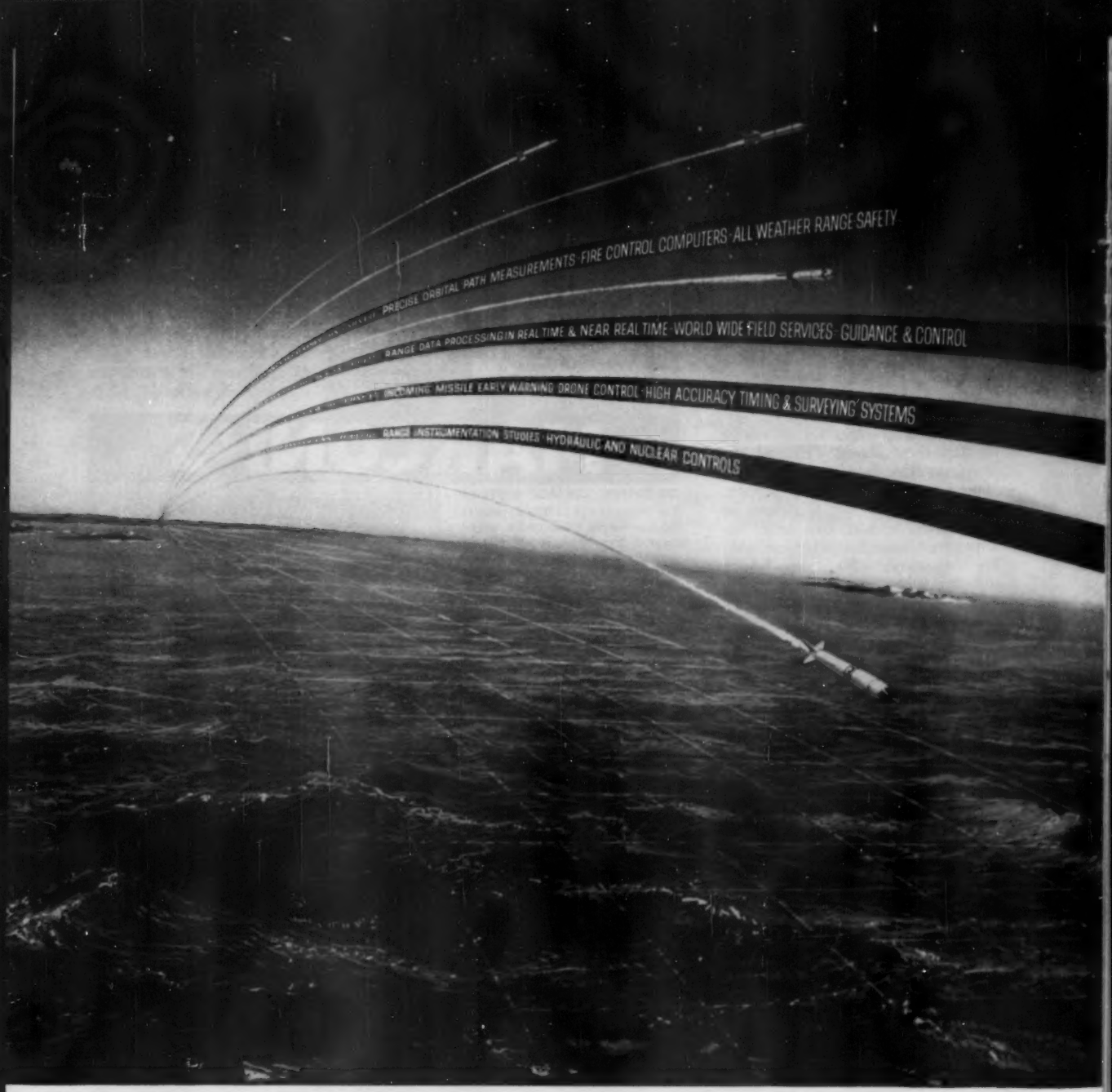
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THE MISSILE RANGE: Measure of Capability

The missile range today is a vast proving ground for advanced technologies. It symbolizes the "state of the art" in computation, physics, chemistry, metallurgy, propulsion, hydraulics, electronics, inertial guidance, communications and every other scientific field.

The most critical need of the missile range is to *know system performance exactly*. This calls for integrated standards of measurement and data handling, and therefore for entire systems and entire installations engineered to that objective.

To this problem Sperry Rand has a logical answer: *compatible instrumentation*. The scope of Sperry Rand capability, illustrated above, embraces the whole panorama of the space age. Compatible Instrumentation is the principle of precision in missile range measurement, and a plan of action for applying this principle to projects now developing.

For the necessary team approach to missile range technology Sperry capabilities are joined with those of all other corporate divisions which have contributions to make—among them Ford Instrument Company, Remington Rand Univac, Vickers Incorporated and several component divisions specializing in microwaves, electronic tubes and solid state devices. General Offices: Great Neck, N. Y.

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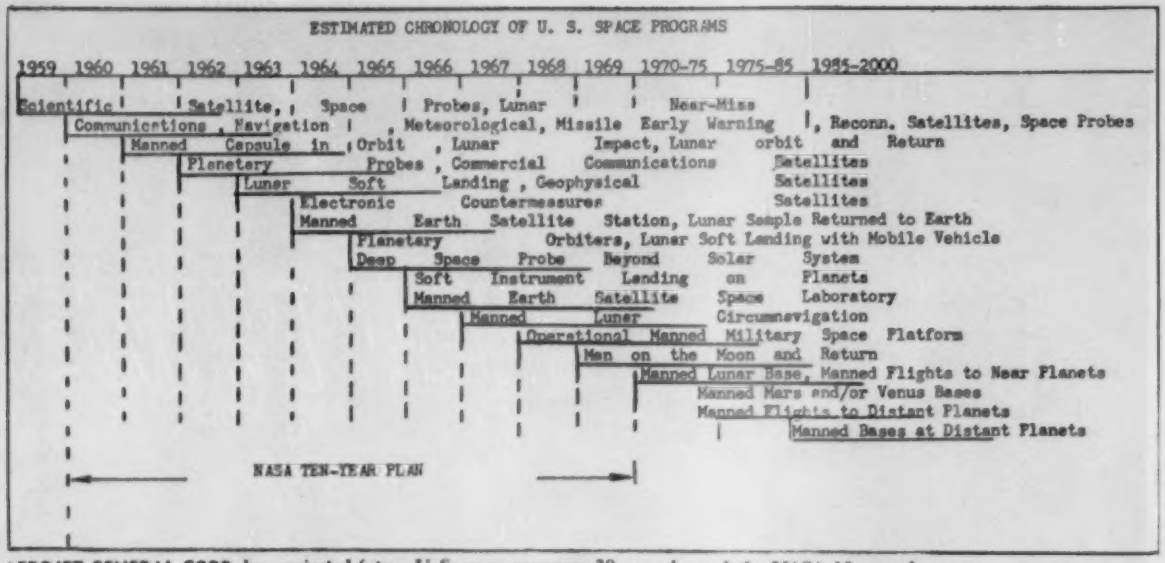

ESTIMATED CHRONOLOGY OF U. S. SPACE PROGRAMS
1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970-75 1975-85 1985-2000
Scientific Satellite, Space Probes, Lunar Near-Miss
Communications, Navigation, Meteorological, Missile Early Warning, Recon. Satellites, Space Probes
Manned Capsule in Orbit, Lunar Impact, Lunar orbit and Return
Planetary Probes, Commercial Communications Satellites
Luner Soft Landing, Geophysical Satellites
Electronic Countermeasures Satellites
Manned Earth Satellite Station, Lunar Sample Returned to Earth
Planetary Orbiters, Lunar Soft Landing with Mobile Vehicle
Deep Space Probe Beyond Solar System
Soft Instrument Landing on Planets
Manned Earth Satellite Space Laboratory
Manned Luner Circumnavigation
Operational Manned Military Space Platform
Man on the Moon and Return
Manned Lunar Base, Manned Flights to Near Planets
Manned Mars and/or Venus Bases
Manned Flights to Distant Planets
Manned Bases at Distant Planets
NASA TEN-YEAR PLAN

AEROJET-GENERAL CORP. has projected future U. S. space programs 30 years beyond the NASA 10-year plan.

nents than could travel by rail or highway.

Typical of the proposals made to ARDC is that of Thompson Ramo Wooldridge. It calls for construction of an offshore platform which would be anchored to the sea bottom after it was towed to the launch area.

There would be pilings supporting an underwater substructure containing the control center for a launching. Above this would be a launching platform which could be replaced in the event of an accident, leaving the control complex unharmed. TRW proposal specifies about 150 of these platforms, to be built after development of the launch vehicles. Cost would be about $6 million each.

Different Approaches

Aerojet-General proposals include several different approaches to launching at sea. One includes an idea similar to the TRW tower. Another would make the entire rig capable of floating in deeper water and being towed anywhere the water is 400 ft. or more deep.

In preliminary company-funded work, Aerojet and Todd Shipyards have built a ship similar to a floating drydock which would carry a vehicle to sea in a horizontal position. On station, the launch vehicle would be erected, the ship would be partially submerged, then the vehicle would be launched. The size of this experimental ship would permit current boosters and those planned for the immediate future to be launched.

The principal concept studied by Aerojet, however, is known as PROP, for Planetary Rocket Ocean Platform, which is said to meet all the requirements for assembling, testing and launching very large vehicles. It is especially suited for launching of nuclear rockets, the company says, because of the isolation inherent in remote sea areas and the availability of unlimited quantities of sea water for nuclear shielding.

As proposed, PROP would accommodate a vehicle 40 ft. in diameter and 300 ft. long. The superstructure would be above the reach of high seas. It would be supported by buoyant chambers below the wave forces of such seas.

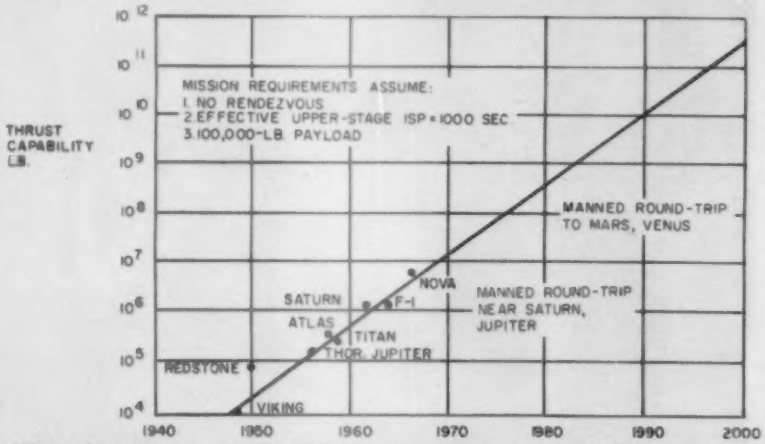
Logistic supply would be by ship. A shipboard crane would hoist the vehicle, housed in a protective cocoon, on deck. After removal from the cocoon, it would be let down into the central tube where prelaunch final assembly and checkout would be accomplished out of the reach of the weather. After preparation, vehicle would be hoisted to firing position on the platform.

After a normal nuclear launch, or in the event of a nuclear accident which would destroy the platform, personnel in the control areas in the buoyant outer ring 125 ft. below the surface would be evacuated by a submarine through an airlock. After a normal launch, a number of decontamination procedures would be carried out. Reconstruction after an accident would involve only the work on the platform and crane, and there would not be the radiation contamination that would normally have to be considered at a land installation.

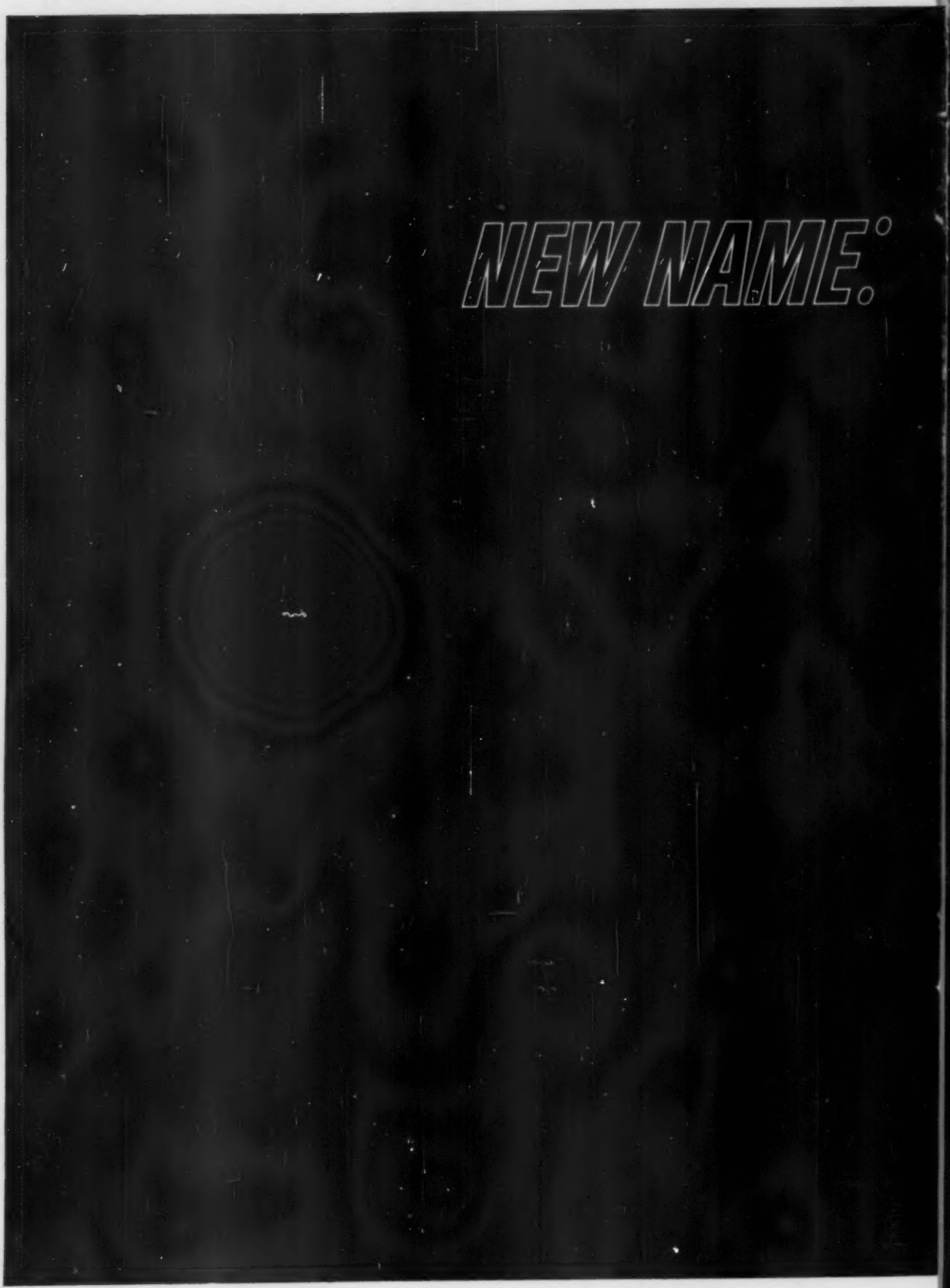
Concept Is Variable

Aerojet points out that its concept is not static. It can be varied for size of vehicles, functional capacity and mode of operation.

Another Aerojet concept, which could be used in conjunction with PROP or fitted into another system, would have



GRAPH shows future booster capability with new propulsion systems (AW Dec. 5, p. 38).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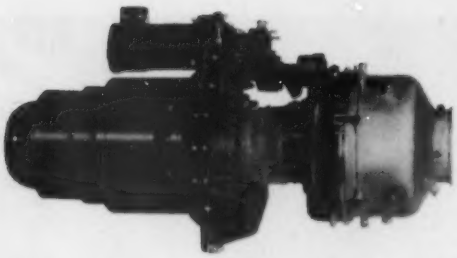

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the vehicle towed to sea from a seaside construction site.

This alternate system calls for a floodable sponson to be attached to the firing end of the vehicle. At the firing site, the sponson would be flooded at its farthest end, automatically erecting the launch vehicle to the vertical position for firing.

An extension of this system involves firing from the sea bottom in relatively shallow areas.

Martin Co. has studied independently a tanker concept for supplying remote or sea-based launching sites with propellants (AW Sept. 5, p. 68).

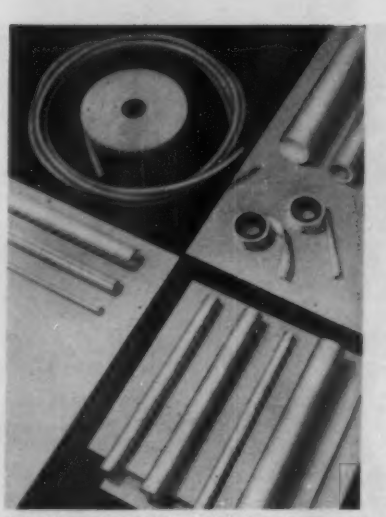
NASA, Air Force and the Navy all are careful to point out that the sea launch is still in the exploratory stage. They feel however, that with increasing size, weight and propulsion complexity, launchings may have to make use of the ocean areas. Specific system designs will have to wait for vehicle development, when their configurations and operating capabilities will be known.

On missile bases, Air Force estimates that multiple launch sites hardened to 100 to 300 psi. would make any attempt to knock them out uneconomical. Current yardsticks for 10-megaton bursts show that 5 psi. structures would be destroyed at 15,000 yards from ground zero. Costs for hardening to 100 to 300 psi. have not been published. Some Air Force officials have even discussed hardening to 10,000 psi. These site hardening costs could be avoided by using the sea launch approach.

In launch aborts, the greatest cost is in reconstruction of the installation. This not only involves high cost but the loss of valuable use time of a specialized complex. These factors would be greatly diminished in sea launch operations.

Tiros II Satellite Atop Thor-Delta

Tiros II weather observation satellite, launched into orbit recently from Cape Canaveral, Fla. (AW Dec. 5, p. 28), is shown atop a Douglas Thor-Delta rocket launching vehicle before installation of the nose fairing.



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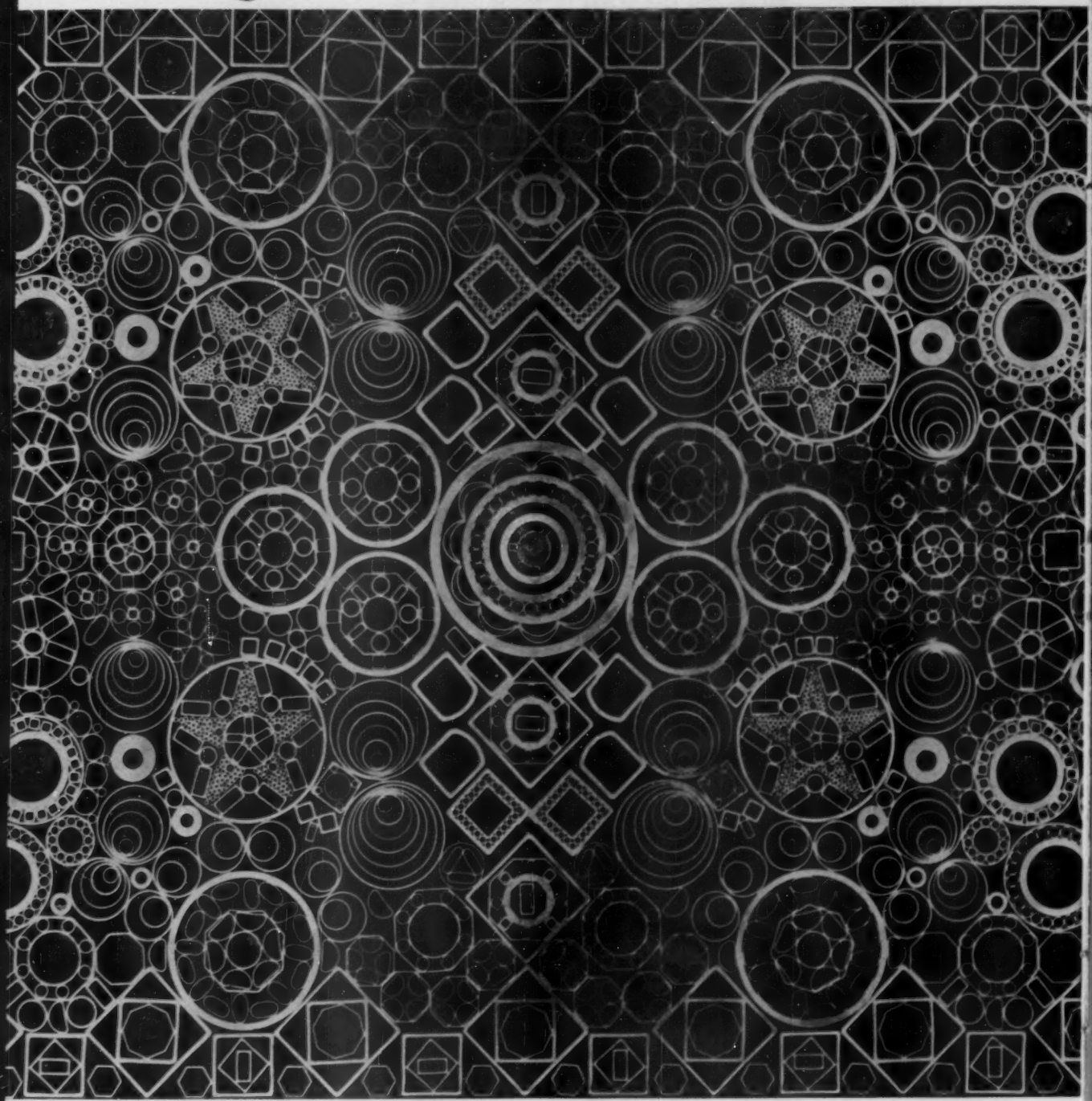

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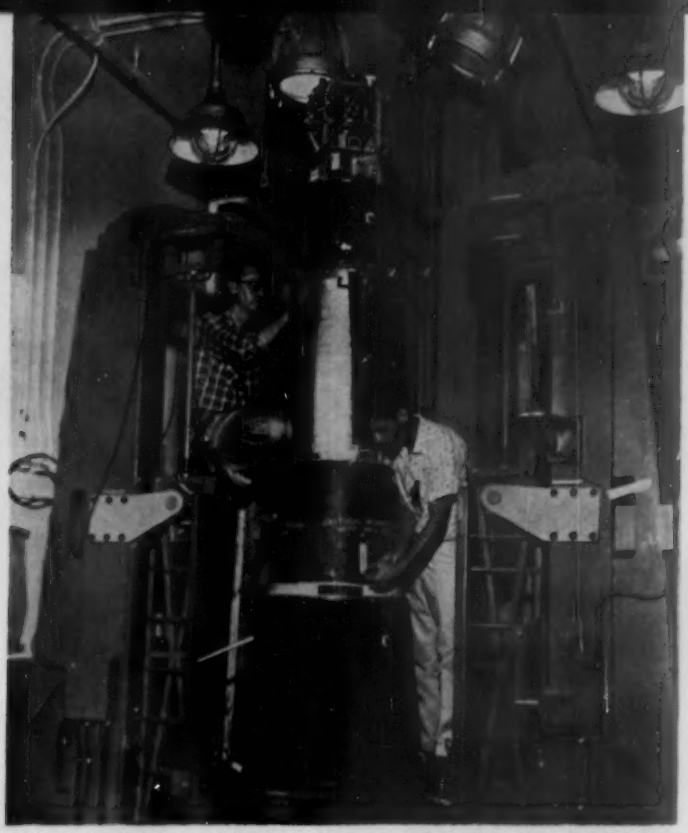
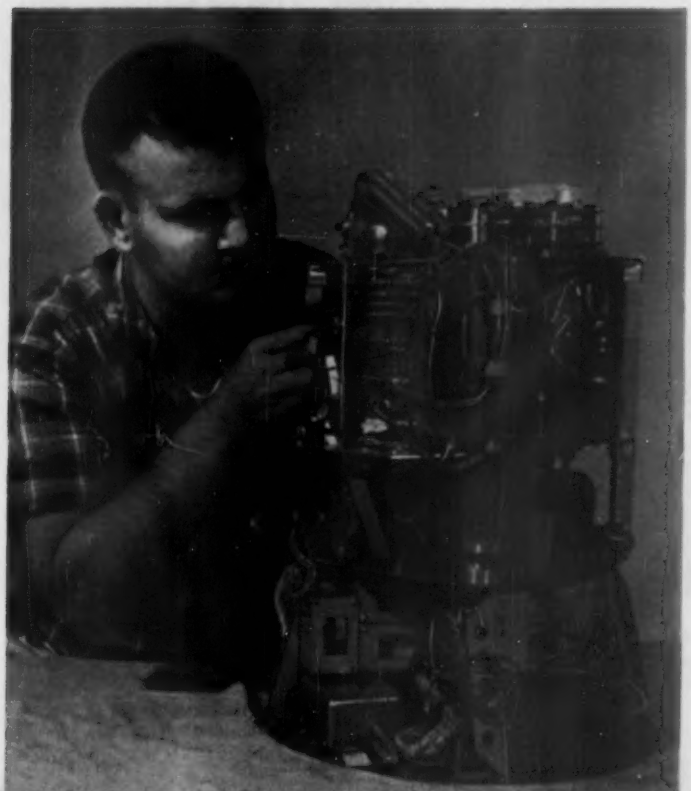
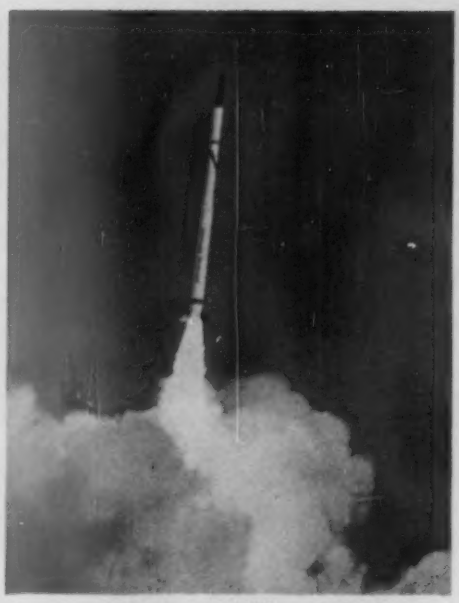


Payload, fourth stage and interstage connectors of the first successful four-stage Scout are assembled at NASA's Wallops Island, Va., station.

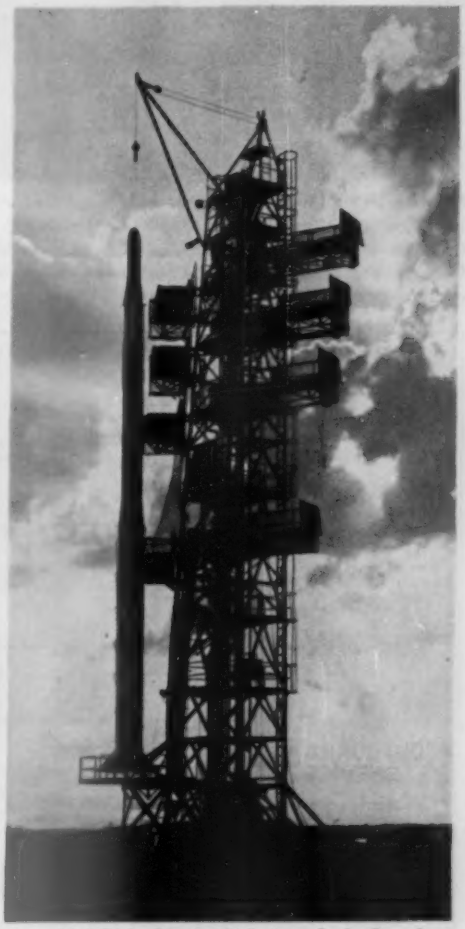
NASA Launches Four-Stage Scout On Developmental Test Flight

Instrumentation is installed on the payload section of the first successful Scout vehicle. Payload contained USAF radiation-measurement equipment and instruments to monitor flight performance of the fully-guided Scout.





First completely successful firing of the four-stage Scout vehicle carries a USAF payload on an 80-min. probe to 3,500-mi. altitude and range of 5,800 mi.



Assembled 72-ft. Scout vehicle is ready for launch at Wallops Station. Vehicle weighs 36,000 lb. and is largest all-solid-propellant vehicle launched by U.S.

NASA Programs Saturn Booster Recovery

New York—No attempt will be made to recover boosters in the initial Saturn test flights, but booster recovery is definitely scheduled later in the Saturn program, according to Dr. Wernher von Braun, director of the National Aeronautics and Space Administration's Marshall Space Flight Center.

NASA was planning to start a new series of 6-8 static tests of the 85-ft. Saturn at Marshall last week in a development program leading to the first test flight next summer.

Von Braun said that recovery will not be tried in the first tests in order to keep the tests as simple as possible. He said, however, that spent booster recovery will be the next major method to reduce space transportation payload costs per pound. Saturn will put one pound of payload into orbit for $500, compared with $1 million per pound for the first Vanguard, he said.

Recovery Technique

Recovery technique will involve use of a control system to orient the casing in a tail-down attitude as it re-enters the atmosphere. After re-entry, a conical drag-stabilization balloon will deploy.

Landing system consists of three cargo parachutes.

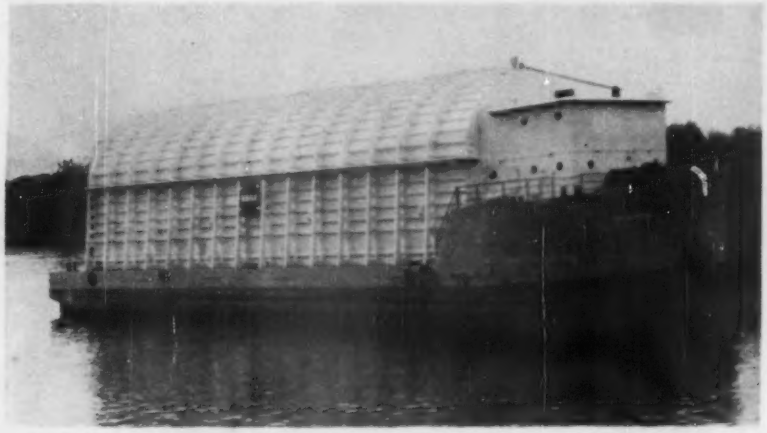
At 100-ft. altitude, solid propellant retrorockets will ignite to reduce landing velocity close to zero.

Spent booster will follow a ballistic trajectory into an estimated 5-mi. dispersal area, where a landing ship dock (LSD) will be stationed for retrieval.

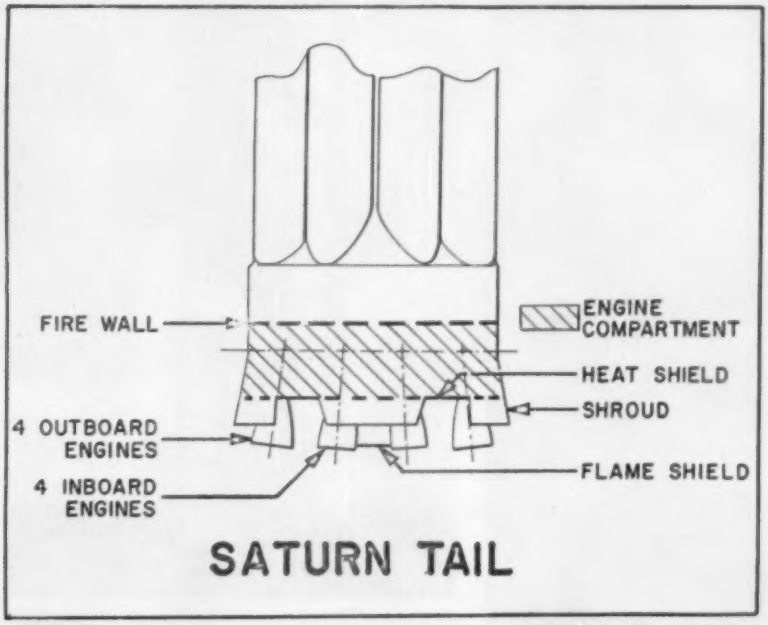
New test series beginning at Huntsville, Ala., will use booster chambers approximating those of the flight vehicle.

Two tests of the clustered eight engines are planned for duration of less than 30 sec., and the rest will run 100 sec. or more.

Each engine will develop 165,000-lb. thrust initially, and the system will be developed so that ultimately each will develop 188,000-lb. thrust.



PALAEMON, a 180-ft. long, 38-ft. wide barge that will transport NASA's Saturn heavy space booster to its launch site at Cape Canaveral next year for its first flight test, arrived last week at the Marshall Space Flight Center, Huntsville, Ala., after a 16-day trip from Houston, Tex. Built by the Todd Shipyards Corp. of Houston, the barge contains its own electrical power source, instrument room, kitchen, sleeping for 10 persons.



LOCATION of shielding to protect against radiated and conducted heat generated in Saturn captive tests is shown in this drawing of the tail section of the booster.

First Tests Successful

First series of eight captive tests was completed in June, and von Braun said they were "100% successful" in establishing the feasibility of clustering large liquid rocket engines.

Current series will use engine chambers with heavier shielding added to the tail section. Heat shield has been installed at the nozzle throat level, and a flame shield has been installed between the nozzles of the four inboard engines. Fire wall has been installed below the fuel and liquid oxygen tanks, and a lower shroud has been added to encase the engine down to the level of the flame.

Test program is being run to determine general engine performance, using 900 data channels to record information on vibration, pressure, temperature, acoustical measurements and fuel consumption rates.

Sound Distribution

Measurements will be made on the booster, the test tower and in the adjoining area to determine sound distributions caused by addition of the lower shroud.

In other Saturn developments, Marshall is evaluating proposals for a study contract for automated test equipment for the booster stage, and Douglas Aircraft Co. has been awarded an $85,000 contract to study operational aspects of the second generation Saturn C-2 configuration.

Douglas study, due in eight months, will examine production, recovery and reconditioning, checkout, static test, transportation, launch site operations and facilities and flight evaluation.

SAC'S MOST UNUSUAL MISSILE

To enemy radar, these are all B-52's. Altitude, performance, radar return and flight patterns confirm this.

But two of these bombers are decoys . . . diversionary missiles to lure the firepower of the enemy away from target-bound B-52's.

Each SAC B-52 can carry McDonnell GAM-72 Quails in addition to its prime target bombload. By simulating the characteristics of the parent aircraft and saturating enemy defense systems, the GAM-72 greatly increases the deterrent potential of a bomber striking force yet costs less than 2% of the cost of a B-52.

McDonnell is now delivering GAM-72 missiles, launch gear, support equipment and bomber controls to Strategic Air Command operational squadrons.

For illustration suitable for framing write: Dept. 80, McDonnell Aircraft St. Louis, Mo.

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Ship Provides Precise Missile Tracking

Cape Canaveral, Fla.—Absolute measurements of missile trajectories down the Atlantic Missile Range will be provided by the newest USAF downrange vessel, Twin Falls Victory, using the missile's launch stand as the reference point for the tracking operation.

To perform precision tracking, Twin Falls is fitted with AN/FPS-16 (tracking) and SPN-8 (surveillance) radars, N7C inertial platform, Mark-19 gyro compass, UHF transmitting and receiving antennas and high-frequency LORAC (Long Range Accuracy) radio positioning equipment. The ship will begin operating by mid-1961 with flight tests of the Army's solid-fueled Pershing surface-to-surface missile. Range of the vessel will be about 500 mi., but this can be extended without difficulty when more downrange geographical points or additional LORAC sites are more precisely located for the ship to position itself.

Previously, only land-based tracking stations have made absolute (three-dimensional) measurements, within an error of 0.2 mils (20 ft. per 100,000 ft.). Twin falls is expected to begin operations within 1 mil and improve with time. Biggest advantage of the vessel is its ability to move into varying target areas and meet requirements of different programs. USAF also feels that quality of tracking data should improve and that the range safety problem should be considerably alleviated by programing more shots toward open seas.

LORAC sites, on which the Twin Falls will position itself, have been located by first-order coast and geodetic surveys. Two networks, one comprising sites at Jupiter, Fla., Grand Bahama Island and Carter Cay, a Bahama bank island, and the other including Carter Cay, Great Stirrup and Eleuthera, will lay down base lines developing hyperbolic patterns. Phasemeters aboard the vessel will read the shifts between lanes of the patterns and, from previously-computed relationships between lanes and longitude and latitude, the Twin Falls will be able to determine its position within 30 ft.

Radar operation of the Twin Falls consists of two modes—acquisition and tracking. Land-based stations will first pick up the missile's flight on their radars and transmit azimuth, elevation and range data to the ship through radio links. With this information precomputed trajectory tapes and knowing both its position and the position of the launch stand (also determined by first-order coast and geodetic survey), the FPS-16 will search until it locates the missile. Once located, the radar will lock on its tracking mode and the data fed into a computer.

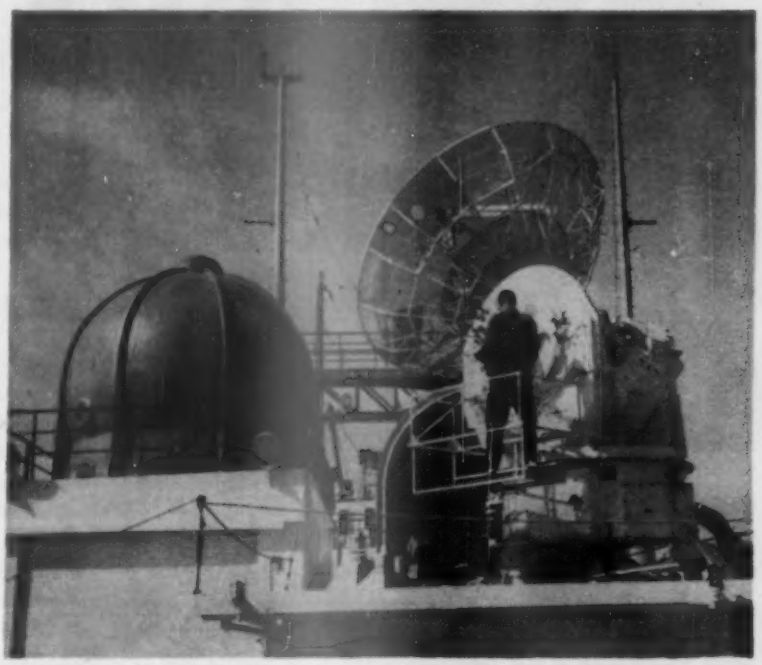
The N7C inertial platform records the pitch, roll and yaw of the ship and the rigidly-mounted radar platform. This information is also fed into the computer, where data processing corrects radar angle data with angle data from the stable platform. Corrected information is then stored on magnetic tape.

SPN-8 surveillance radar is used for impact location and is similar to carrier-based GCA radar.

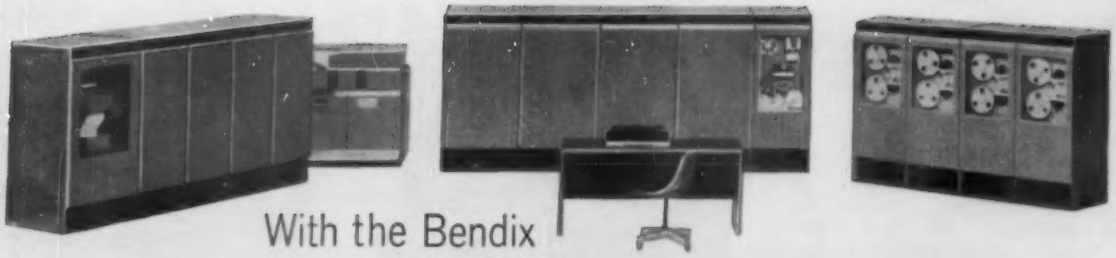
Corrected tracking data will be transmitted to overhead downrange aircraft on UHF transmitters and flown back to the Cape, eliminating the necessity of the ship's return to port.

Total cost of conversion, including all equipment described above, was $10

TWIN FALLS VICTORY, newest USAF downrange vessel, will make absolute measurements of missile trajectories. Twin Falls, built in 1945, is 455-ft. long with a 62-ft. beam.



ENGINEER checks out precision tracking AN/FPS-16 radar aboard Twin Falls. Angular tracking data of the radar is corrected by stable inertial platform in room beneath pedestal.



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million. Pan American World Airways, Guided Missiles Division, was responsible for integration of all systems aboard the vessel, with Electric Boat Co. responsible for installation of the instrumentation system. Alabama Drydock and Shipbuilding Co., Mobile, Ala., did the conversion work.

Twin Falls will carry a crew of approximately 60. Pan American will provide a ship operations manager, five weather technicians and two supply technicians. RCA will provide about 30 technicians to operate the radars and instrumentation.

PRODUCTION BRIEFING

Food Machinery and Chemical Corp., San Jose, Calif., has received two contracts totaling $4,947,000 on the Mauler air defense missile system from Army Ordnance Corps and from Convair-Pomona, prime contractor on the system. Army award calls for design and fabrication of lightweight tracked vehicle to carry the Mauler. Convair contract is for design and development of pod assembly for the missile system.

Lockheed Missiles and Space Division plans a $4 million expansion program consisting of a 172,800 sq. ft. engineering and laboratory building. Work on the project is scheduled to begin early in January and the building is to be ready for occupancy in June.

Propulsion Development Laboratories, Inc., has received an order for 144 boom-mounted pitot tubes for the Northrop T-38 Talon supersonic jet trainer. The $200,000 order from Norair Division of Northrop Corp. brings to 253 the number of units ordered in the last 60 days. Press Temp, a division of Propulsion Laboratories, Inc., will manufacture the pitot tubes.

Austrian Defense Ministry has contracted with Saab Aircraft Works, Linkoepping, Sweden, for 15 Saab 29F type ground support and fighter planes valued at around $2 million. Delivery will begin next spring.

Grumman will equip the SA-16 Albatross amphibian with a magnetic anomaly detection (MAD) tail stinger, sonobuoys, air-to-surface radar and electronic countermeasures equipment for NATO anti-submarine warfare missions. Modification is being performed by Grumman through the U. S. Air Force under a $1,648,000 Military Assistance Program contract.

Chance Vought Aircraft's Electronics Division has received a contract for video correlators, covering nearly $100,000, from U. S. Marine Corps. Weighing 10 lb. and occupying less than ½ cu. ft., the devices will be fitted to ground-based radars. Units have been sold previously for airborne application in Navy aircraft; this is first ground-based service application of Chance Vought device.

Air Force will install an AN/FPS-49 tracking radar at the Thule Ballistic Missile Early Warning System Station, a reduction for economy reasons from the three radars originally planned. BMEWS facility has been built so more tracking radars can be added without construction of new buildings.

Collins Radio Co. will erect a $1.8 million manufacturing building at its Richardson facility, near Dallas, Tex. New building will contain 117,000 sq. ft. of floor space and is scheduled for completion Aug. 15, 1961. Construction is being handled by Alpha Corp., a Collins subsidiary.

Northrop's Nortronics Division Q-ball attitude sensor, projected for service in the North American X-15 out-of-atmosphere research plane (AW July 20, 1959, p. 52), is scheduled to be flown for first time this week in the No. 1 X-15 aircraft powered by interim twin rocket XLR-11 powerplants.

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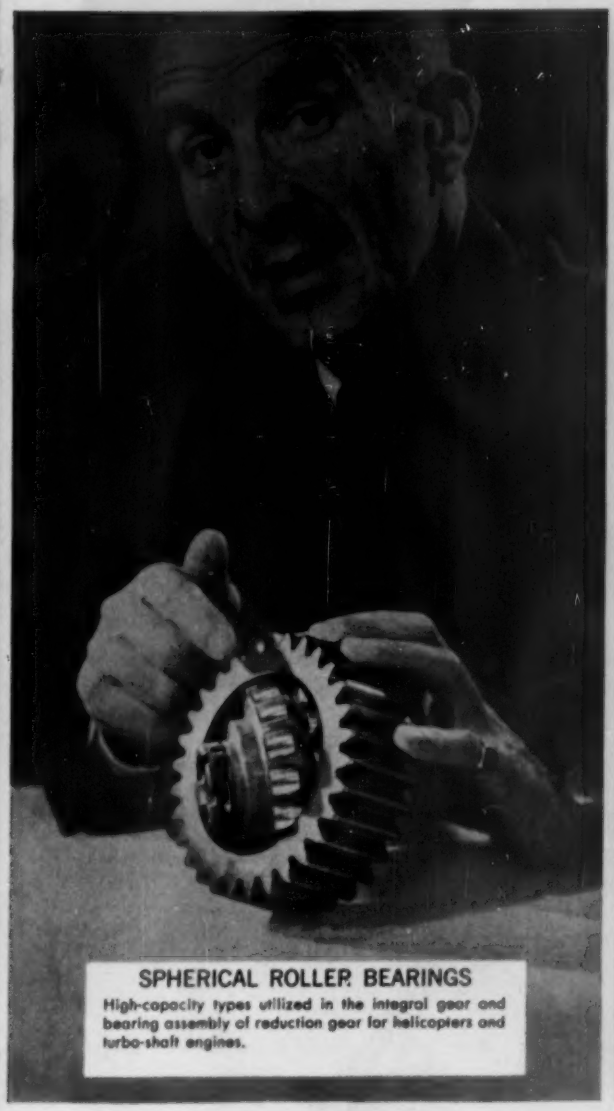

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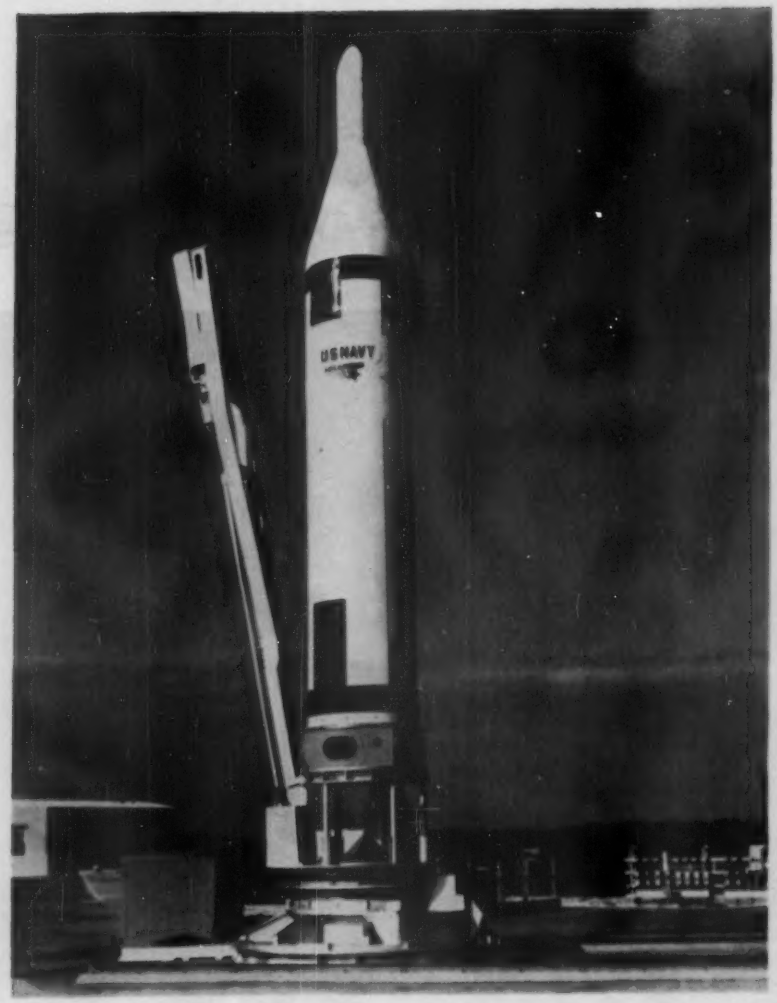
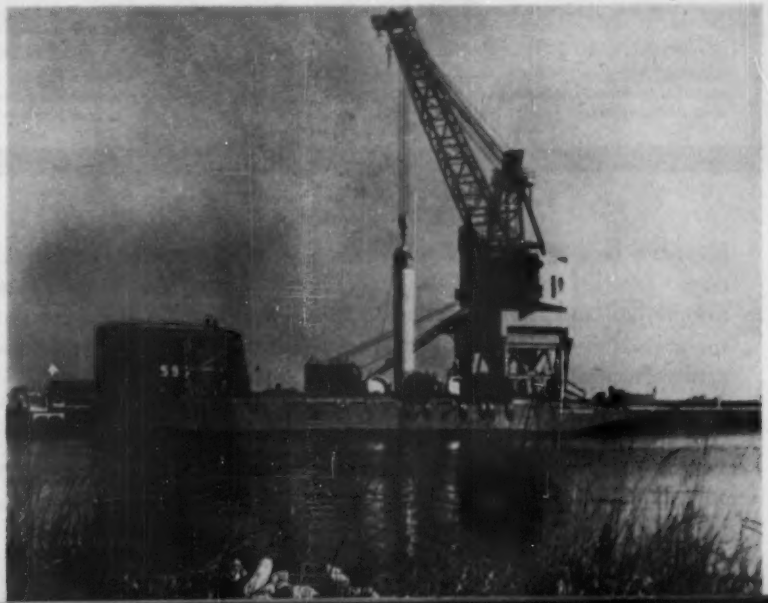


Polaris A2 at Cape Canaveral Site

First Navy-Lockheed Polaris A2 test flight, which has been test fired at Cape Canaveral, Fla. (AW Nov. 14, p. 38), is shown on stand. Missile flew 1,600 mi. and its Aerojet-General second stage is 30 in. longer and several hundred pounds lighter than A1 first stage (AW Nov. 7, p. 27). Below, Polaris A1 canister is lowered into a launch tube on the USS George Washington submarine, now on patrol duty (AW Nov. 21, p. 29).



Supersonic Transport Checkout Studied

New York—Use of automatic checkout equipment to monitor supersonic transport systems in flight and to automate their maintenance on the ground will require design of the systems from the ground up with checkout compatibility in mind, according to members of the American Society of Mechanical Engineers who met here recently.

Computer-centered checkout systems to speed troubleshooting and maintenance of the highly expensive and complex Mach 3 airplanes will be an economic necessity, participants in the ASME aviation session stressed.

The engineers acknowledged that automatic checkout could have improved the utilization and maintenance economics of current jet transports. But systems design went ahead without provision for such an approach and it is too late to retrofit.

With the supersonic transport, however, where a saving of an hour a day on the ground would be worth $3.5 million a year to the airline operator, the designer must provide maintenance performance to match flight performance, according to two Convair experts.

Universal Tester

Use of a single universal type tester for checkout and troubleshooting was discussed in a joint presentation by Eric R. Woods, avionics design specialist of Convair, and Charles L. Blake, Convair's transport systems development manager. This tester might be the size of a suitcase.

Heart of the checkout system is a digital computer of the type used for control and data processing. Operating under its control are stimulus generators and measurement transducers not conveniently integrated with the aircraft.

Provision is made for self-test of the system and self-fault-isolation. This device could complete a comprehensive ground checkout in a few minutes, including fault isolation where desired.

Use of an airborne unit also appears desirable, according to the Convair scientists, thus assuring test support at all times. The in-flight unit would be part of an integrated system keeping the crew constantly informed of aircraft system status.

In an emergency, the computer could initiate corrective action and advise the pilot of the situation for further action.

Along with the "design-for-maintainability" program using computer techniques, the Convair engineers stressed the need for a "design-for-reliability" program in building the supersonic transport. Based on the statistical reliability principle, this program would involve the use of a reliability model programed on a digital computer. Functional analysis of each aircraft system is made in a closed loop operation where reliability deficiencies are fed back into the design and the process repeated until reliability objectives are met. With this technique, the equivalent of thousands of hours of system operation are analyzed before the system is committed for use in the airplane.

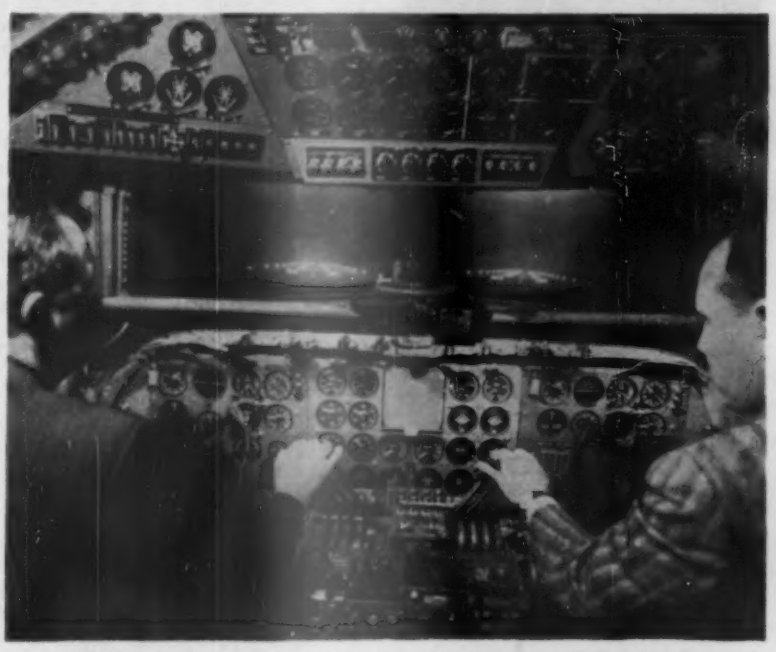
These reliability and maintainability programs are closely related to achieving optimum airplane systems including their logical structure and compatibility with data access and checkout procedures. An important consideration is packaging of the aircraft systems; components should be grouped into well-planned, logical subassemblies or modules.

Cost of the capability for automated checkout would be 2.5% higher than similar procedures under today's methods, Blake said, and bringing all check points to one location and automating them would add .3%, for a total increase of 2.8%. But, by saving 1% in manufacturing costs and one hour a day of ground time, more than 20% of the aircraft purchase price could be recovered in a year.

Present Systems

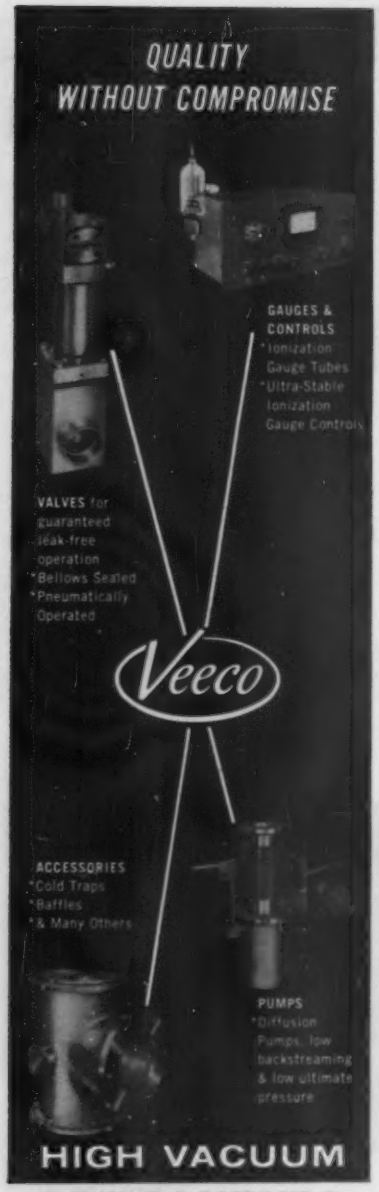
Two North American Aviation, Inc., engineers, in another discussion of system test techniques, called the present system of periodic ground checkout "less than satisfactory" for supersonic transport operation. Period checkout times are set at predicted points beyond which confidence level in the equipment's reliability can no longer be allowed to decline.

But the Mach 3 transport with its high costs, greater demand for takeoff reliability and increasing pressure for



United Orders Dalto Dual-Image Simulator

Dual-screen visual flight simulator for use with Douglas DC-6 simulator has been purchased by United Air Lines from Dalto Corp., Norwood, N. J., for use at United's Denver, Colo., training facility. Previous installations used single screen or projection. System consists of a closed circuit television system and a belt on which approach and runway light patterns are depicted with fluorescent paint, activated by ultraviolet lamps. Belt moves toward the DC-6 simulator at the relative speed at which the simulator is "flown." In the cockpit are W. J. Samuels, left, United's simulator training manager, and Dave Shroyer, United flight instructor.



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Novel two-phase permanent-magnet synchronous motor was designed and built by Bill McLellan, Electro-Optical Systems, Inc., in response to $1,000 offer made by CalTech scientist to anyone who could construct so diminutive a device. Using a watchmaker's lathe, a microscope and a sharp toothpick, McLellan fabricated the tiny 13-part electric motor, shown next to head of an ordinary household straight pin. Device weighs 250 micrograms, occupies $\frac{1}{64}$ cu. in., produces one micro-horsepower. Company has no commercial plans for the motor, but McLellan collected $1,000.

utilization, requires a new approach to equipment reliability checking, according to A. C. Fulkerson of North American's Los Angeles Division and M. Polack of the company's Autonetics Division.

Such an approach is being used with the North American B-70 supersonic bomber, closest present approximation to the Mach 3 jet transport. The "confidence check" is transferred from the ground to the air by using the B-70's digital-computing and recording equipment to program, control, and analyze automatic in-flight checkout of the aircraft systems. Equipment in the B-70 is to be of a self-checking nature.

Subtle Failures

Magnitude of the systems-maintenance task is increased in the Mach 3 transport well beyond the scope of present maintenance operations, according to the North American engineers. Correct systems operation is a vital requirement not only for economics but for flight safety. Simple visual and functional tests by a maintenance man no longer will be adequate; most failures will be of a subtle nature and will require tests in which dynamic stimuli are applied to the aircraft systems.

These systems in a typical Mach 3 transport might include long-range radar, air-data computer, automatic flight control, variable geometry inlet-duct system, gyro platform system, in-flight magnetic tape recorder, and gen-

example...

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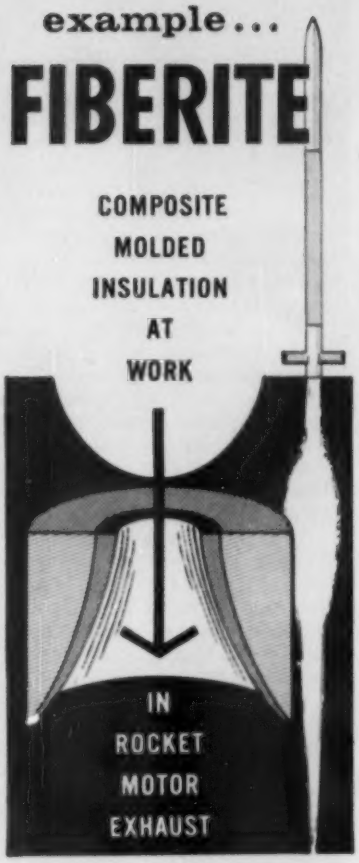
COMPOSITE MOLDED INSULATION AT WORK



Minimum erosion and ablation resistance are needed in exit areas to resist over 5000° F. and high velocities. Excellent results were achieved with Fiberite MX 2630 and MX 2630A. The mechanical strength and thermal insulation were provided by Fiberite MX 2625 with 2630 giving the ablation resistance. By molding these two formulations into a composite structure a superior insulation was developed.

Fiberite compression molded high temperature insulating materials are designed for MIL-M-19536 applications: chopped fiber impregnated phenolic with special reinforcement materials, i.e., fiberglass, graphite cloth, ceramic and quartz. Fiberite insulation is specified in the Lar, Bull Pup, Polaris, Minute Man, Nike Zeus, Red Eye and many others.

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eral-purpose digital computer. Ideally, most "confidence testing" of these systems will be done during flight. Systems will have built-in self-test features and testing will make use of these features as well as of other portions of systems available aboard the aircraft. The program must provide for isolation of subsystem failures to removable units.

When malfunctions are detected by the confidence tests, the terminal will be called upon to isolate the fault to an interchangeable unit, which will be replaced to put the airplane back into the available status.

In a typical airborne test system, the digital computer at the center of the system is the same computer intended to perform navigation, cruise control, collision avoidance and other computations for safe and economical flight. It will be available for the test program on a time-sharing basis. Because there will be priority functions for the computer during flight, a tape recorder will store checkout data for analysis.

Military Systems

Automatic checkout equipment for military aircraft was discussed by R. G. Lohmann, of PRD Electronics, Inc., who reported that two actual applications will be made in the W2F-1 and A2F-1 aircraft.

The W2F-1, a twin-engine turboprop plane, uses a permanent airborne checkout installation, integrated with the aircraft electronic system. This plane carries about five tons of electronic equipment for its AEW work, Lohmann said.

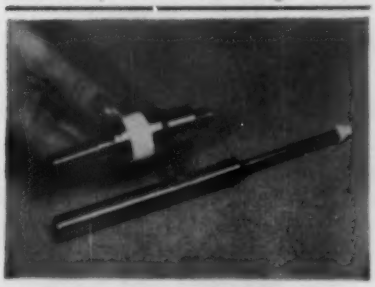
The airborne checkout system will provide continuous automatic monitoring of the AEW equipment while it is operational. It eliminates 90% of the equipment needed on the aircraft carrier deck. The checkout system will increase the aircraft gross weight by .23%, and is only 2.2% of the weight of the equipment being checked, Lohmann said.

In the case of the A2F-1, checkout equipment is on the ground because of space limitations in the aircraft. The system comprises four carts, one containing the test center which operates with one or more of the other carts to perform the system tests.

The airline customer's viewpoint was expressed at the ASME session, part of the society's annual winter meeting, by William Littlewood, vice president-engineering of American Airlines.

Littlewood said subsonic jets could use advanced automated maintenance systems, too. Complexity of checkout equipment discussed, he said, was merely an extension of some of the equipment used already by the airlines —the ignition analyzer for piston aircraft, for example, or the jets' landing gear signal lights. But a prime need in systems design, Littlewood said, was for reliability in the first place: "If things were built right in the first place, we wouldn't have to check them so much in the second place."

Any ground checkout system for airline use, Littlewood said, should be designed so that ordinary mechanics could spot the trouble, take out and replace a



Thermionic Converter

Experimental thermionic converter, one of two units recently delivered to Air Force by Thompson Ramo Wooldridge in association with Thermo Electron Engineering Corp., Cambridge, Mass. TRW has USAF contract to build experimental vacuum and vapor type thermionic generators capable of producing 250 watts of electric power.

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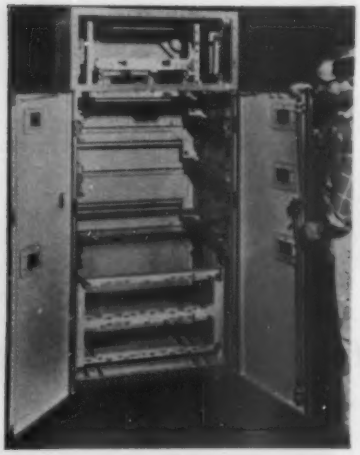

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unit, and let the airplane go on its way. There is a requirement, he said, for logical subdivision and unitization of systems, and units must be removable without interfering with connections to neighboring units.

Littlewood suggested that the "sudden great interest" in checkout systems might stem from manufacturers' fears for supersonic transport safety as well as economic problems.

Regarding the supersonic transport, Littlewood said such an airplane "is just a dull ember—not even a glow in the eye of its prospective father" at this point. The B-70 will provide experience for such a program, he said, which might get under way about five years hence.

Shock Device Tests Near-Miss Reaction

Shock conditions simulating those of near-miss thermonuclear attack have been built into a tune spring shock machine by the American Laboratories Division of American Electronics, Inc., Fullerton, Calif. Machine will test reactions of launch crews at hardened ballistic missile sites to various shock levels and their ability (1) to remain seated or standing and (2) to perform complex tasks during and after shock.

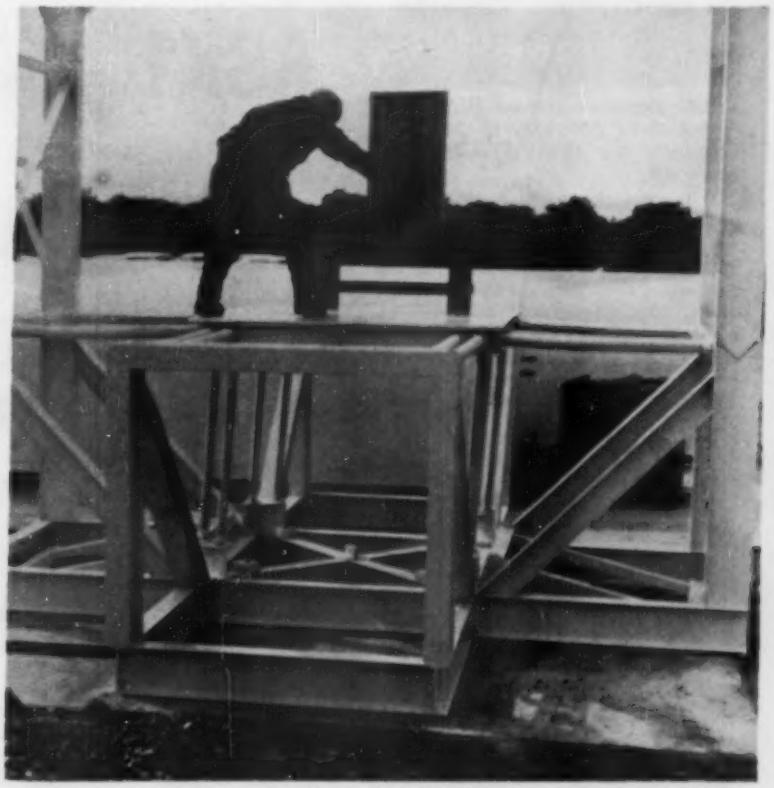
In all hardened Atlas, Titan and Minuteman sites, main floor areas are suspended from large shock absorbers. High over-pressure shocks caused by nuclear attack would be transformed into lower gravity forces, but with high-amplitude, low-frequency floor oscillations and equipment displacement.

Tests conducted at American Laboratories' plant will determine human tolerances to shock frequencies and durations. Other tests include increase in blood pressure, blurred vision, coordination, nausea and balance compensation.

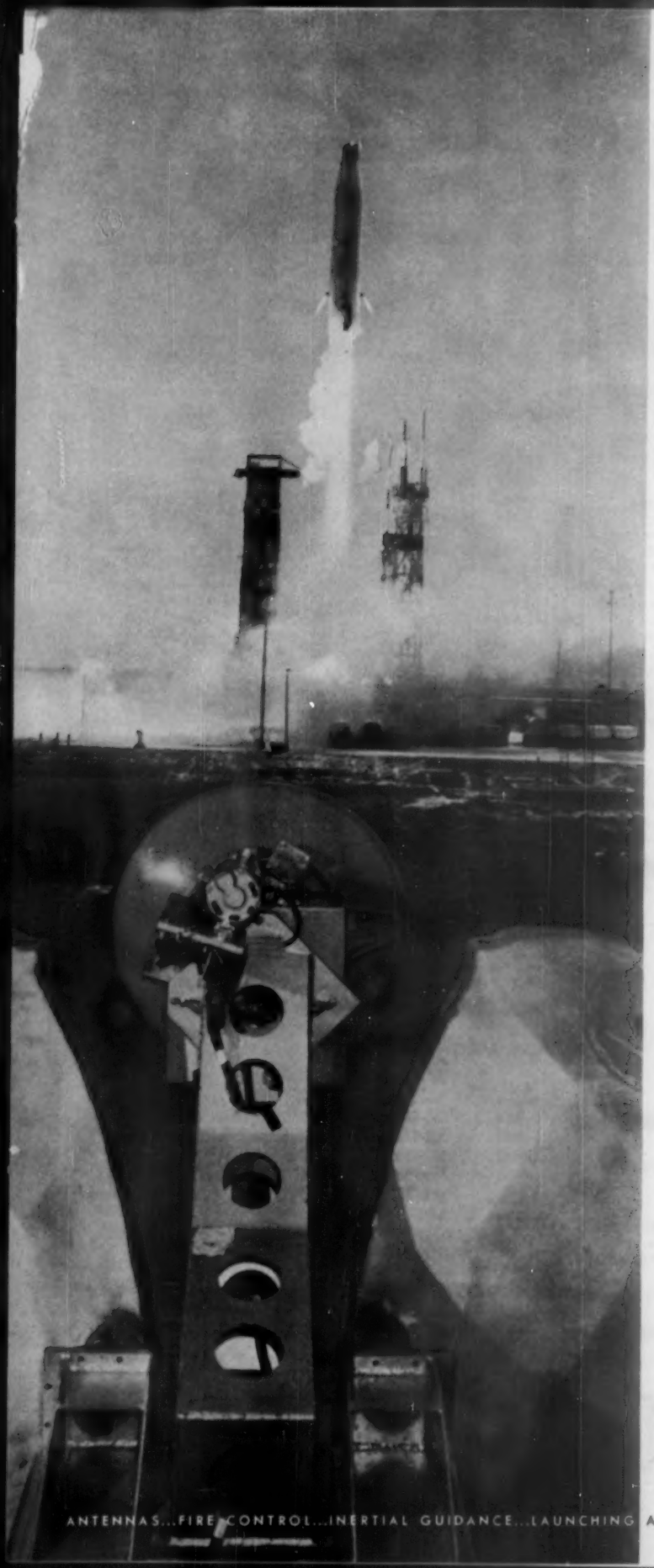
Lycoming Receives T53 Follow-On Award

Production of the Lycoming T53 gas turbine will continue under an $8.6-million Air Materiel Command contract.

The contract award, made by the Aeronautical Systems Center, Wright-Patterson AFB, to Lycoming Division of Avco Corp., Stratford, Conn., concerns turboshaft T53-L-5 engines for the Army's Bell HU-1B helicopter and turboprop T53-L-3 versions for the Army's Grumman AO-1 Mohawk.



SUBJECT being tested on shock simulator at American Laboratories, Fullerton, Calif., finds it difficult to operate controls on standard electronics rack. American Laboratories says that ballistic missile launch crews may have to be equipped with crash helmets, magnetic shoes, safety belts and padded clothing to withstand shock forces of near-miss thermonuclear attack.



ANTENNAS

AS ATLAS SPED 9000 MILES for a Free World distance record, the U.S. Air Force ATLAS Radio Command Guidance System precisely guided the missile into correct trajectory, then instantly cut off propulsion at the exact combination of position and velocity needed to hit the target.

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Type Number	Frequency Range Megacycles	Peak Power (Minimum) Megawatts	Cathode Pulse Length Microseconds	RF Duty Ratio	Remarks
L-3270	1250 to 1350	2	8	0.0025	Broadband (100 megacycles between 2 megawatt points)
LT-7504 (L-3035)	1240 to 1360	2.2	8	0.0025	Long range search radar
L-3257	1280 to 1330	4	30	0.0003	For linear accelerator
L-3227	1280 to 1330	5	8	0.002	For linear accelerator
L-3250	1250 to 1350	10	7.2	0.0015	Long range search radar and linear accelerator
L-3387	1250 to 1350	30	7.2	0.0033	Long range search radar
L-3302	2855	10	7.2	0.0015	For linear accelerator and radar
L-3355	1250 to 1350	20	7.2	0.0015	Long range search radar

TRAVELING WAVE TUBES

Type Number	Frequency Range Megacycles	Power Output	Focusing	Duty Factor
L-3266	7000 to 11,000	20 mw	PPM	CW
L-3236	7000 to 11,000	2 W	PPM	CW
L-3470	4000 to 8000	20 mw	PPM	CW
L-3471	4000 to 8000	2 W	PPM	CW
L-3472*	8500 to 9600 7000 to 11,000	10 W 5 W	PPM	CW
L-3264*	100 to 300	100 W	Solenoid	CW

* *In development*

M-TYPE BACKWARD WAVE OSCILLATORS

Type Number	Frequency Range Megacycles	Power Output	Focusing	Factor	Remarks
L-3148	8500 to 11,000	150 watts minimum	Permanent magnet	CW	No holes in a 1.5/1VSWR

A complete line of M-BWO's is available but classified

PULSE MAGNETRONS

Type Number	Frequency Range Megacycles	Peak Power (Min.) KW	Duty Ratio	Remarks
L-3204	8800±25	0.04	0.25	Extremely high duty
L-3105	9300±40	0.10	0.027	Highly ruggedized; frequency stable
L-3028	9280 to 9320	0.12	0.027	Frequency stable; pulse train capability
L-3379	8800 to 9500*	1.0	0.003	Highly ruggedized; frequency stable
L-3058	9330 to 9350*	1.0	0.003	Frequency stable
L-3358	16,000 to 16,500*	1.0	0.001	Highly ruggedized; frequency stable
L-3380	8800 to 9500*	2.0	0.002	Highly ruggedized; frequency stable
L-3359	16,000 to 16,500*	2.0	0.001	Highly ruggedized; frequency stable
L-3381	8800 to 9500*	3.0	0.001	Highly ruggedized; frequency stable
L-3382	8800 to 9500*	4.0	0.001	Highly ruggedized; frequency stable
LT-6233	9280 to 9345	7.0	0.003	High duty beacon magnetron
L-3103	8500 to 9600*	30.0	0.002	High duty version of LT-6543
L-3168	9375±30	30.0	0.002	High duty version of LT-4J52A
L-3306	16,000 to 17,000*	30.0	0.002	High duty version of L-3083A
L-3083A	16,000 to 17,000*	60.0	0.001	Recommended for new systems
LT-6543A	8500 to 9600*	65.0	0.001	Recommended for MTI systems
L-3305	8600 to 9500*	65.0	0.001	Recommended for frequency diversity
LT-6510	9375±30	65.0	0.001	Recommended for MTI systems
LT-4J52A	9375±30	70.0	0.001	Recommended for new systems
L-3312	8500 to 9600*	200.0	0.001	In development
L-3313	8600 to 9500*	200.0	0.001	Hydraulically tunable for frequency diversity
LT-4J50A	9375±30	225.0	0.001	Recommended for new systems

**Fixed frequency versions available generally throughout tunable range.*

CW MAGNETRONS

Type Number	Frequency Range Megacycles	Minimum Power Watts	Remarks
L-3456	350-590	500	These CW Magnetrons may be pulsed to approximately 2 kilowatts peak power and are recommended for component testing.
L-3459	590-975	500	
L-3465	975-1500	400	
L-3464	1500-2350	400	
L-3460	2350-3575	500	
L-3461	3575-4975	400	
L-3467	4975-6175	400	
L-3468	6175-7275	300	
L-3462	7275-8775	300	
L-3463	8775-10,475	250	

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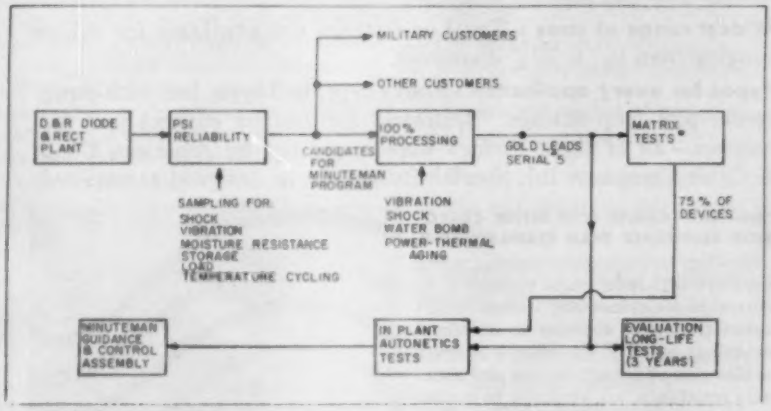
DIODES, slated for design into guidance and control systems of Minuteman ICBM, are subjected to vibration test (left) and visually inspected (right) as part of extensive North American Autonetics directed reliability program at Pacific Semiconductors, Inc. Reliability, or failure rate, of these parts is expected to be raised by two orders of magnitude.

Minuteman Avionics Reliability Increases

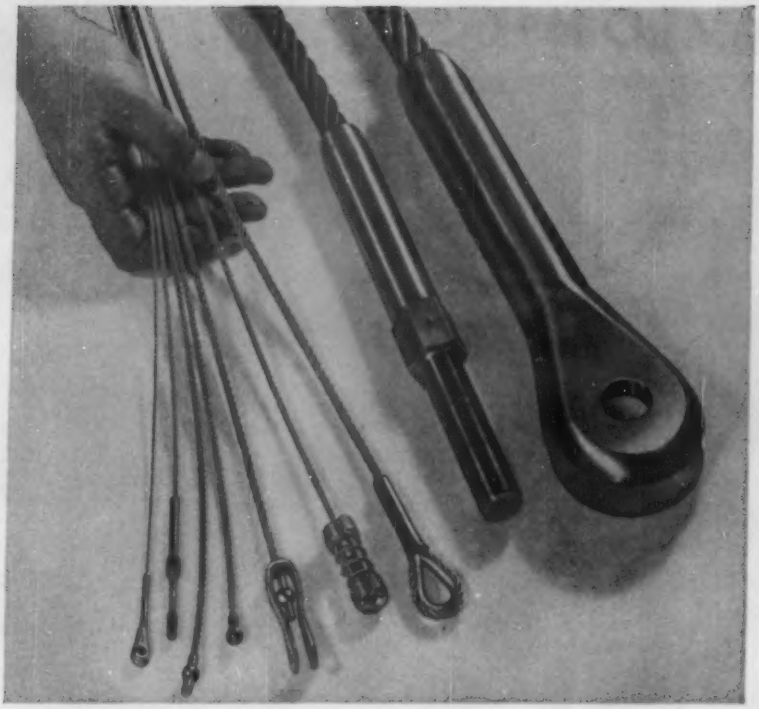
Los Angeles—Partial results of a broad program aimed at boosting reliability of avionic components slated for the Minuteman ICBM show significant progress toward the goal of slashing component failure rates by a factor of as much as 100 (AW Oct. 19, 1959, p. 69).

The program is intended to ensure that components going into the guidance and flight control systems of Minuteman missiles can survive the weapons long periods of watchful idleness in underground silos and the environmental rigors of possible launch and operation. North American Aviation's Autonetics Division, Minuteman associate prime contractor, is tightly supervising the reliability effort.

To date, 13 participating avionic component makers hold subcontracts ranging in value from nearly $\frac{1}{2}$ million to about $2 million to supply Autonetics with the reliable diodes, transistors, capacitors, resistors and transformers required for Minuteman. The contract dollars only cover a portion of the costs—environmental ovens, some special building areas, a few salaries, perhaps a



STEPS in test, evaluation and selection of components destined for the Minuteman ICBM guidance and control systems are shown in flow diagram. Chart indicates steps for three types of diodes made by Pacific Semiconductors, but is also typical for components made by over a dozen other manufacturers for the Autonetics Minuteman component reliability program (AW Oct. 19, p. 69). Pacific Semiconductors' devices are fabricated, undergo series of company reliability tests, and then are available for sale or as candidates for Minuteman program. The latter group is tested further, the bulk of these shipped to Autonetics for additional pruning and testing before going into missile assembly. Groups of components are removed from the flow before leaving component maker's plant for Autonetics-directed Matrix tests; other samples are selected at Autonetics for long-life tests.



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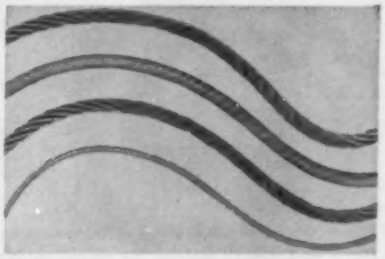

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MATRIX board containing one hundred transistors is placed into environmental chamber for life tests at accelerated conditions. Component manufacturer, Fairchild Semiconductor Corp., hopes to bring reliability of all components up to high level being reached for the Minuteman.

small portion of the components and their testing. The component supplier bears the remaining expense in payment for the component reliability improvement program he might not otherwise be able to shoulder alone. Of course, each manufacturer is being paid additionally for production quantities of their components earmarked for Minuteman.

Participation in the Minuteman program gives each supplier an opportunity, as one put it, of eventually raising all its components to the Minuteman level. Components account for a major portion of the cost of Minuteman guidance/control systems because of large numbers required and the relative low cost of system assembly.

Transistor and Diode Sources

Besides these 13, Autonetics plans to bring other companies into the program as second sources for transistors (now made by Motorola, Fairchild, Delco, Transitron and General Electric) and diodes (supplied by Pacific Semiconductor and Transitron). Four companies—Clevite, Texas Instruments, Fairchild and Transitron—are under consideration as backup supplier for the most widely used component in the system, a silicon computer diode, made by Pacific Semiconductors. Transistor second sources will be selected from another group of 10 or 12 semiconductor companies.

Minuteman components must reach final reliability goals in six ascending time and achievement phases throughout the 18-month program. Suppliers have met the first several phase goals, according to failure rate versus schedule curves prepared as part of the program. For example, Pacific Semiconductors, which provides three types of semi-

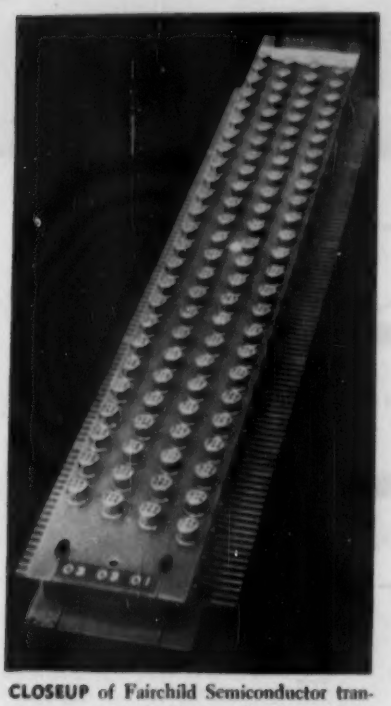
conductor diodes for the program, including the extensively used computer diode, recently reached these levels:

• **Computer diode**—Estimated failure rate of 0.0009% per 1,000 hr. Final goal is an actual failure rate of 0.0002%/1,000 hr., highest reliability goal of any Minuteman avionic component and a reduction by a factor of 100 from the preprogram estimated failure rate. The present figure is factor of 22.2 improvement in estimated rate.

• **High conductance diode**—Estimated failure rate of 0.002%/1,000 hr. Final goal—0.001%/1,000 hr.

• **Low leakage diode**—Estimated failure rate of 0.002%/1,000 hr. Final goal—0.001%/1,000 hr. The preceding failure rate figures are at 60% confidence level. An acceleration factor of 100 is assumed in each case. Similarly, Motorola reports it is not far from a final goal of 0.007%/1,000 hr. with the germanium mesa pnp transistor it supplies to Autonetics. Another supplier, Fairchild Semiconductor Corp., has advanced reliability of its Minuteman silicon transistors at a comparable pace.

What the stringent reliability objectives of the Autonetics program mean may be shown in one way by an example, cited by Marvin Mann, reliability control manager at Pacific Semiconductors, Inc. If every component of a typical home TV receiver were to have the identical mean-time-failure rate required of PSI's silicon computer diode, Mann explains, it might operate continuously without failure for 25,000 years.



CLOSEUP of Fairchild Semiconductor transistors, manufactured for the Minuteman ICBM, mounted on matrix board to simplify handling and to protect them through long periods of storage and testing.

Improved reliability of components for this program results from both better processes and better screening techniques. Processes are continually improved with failure analyses of faulty components found at different test stations in the product flow from manufacture to assembly, at the supplier's plant and at Autonetics. Corrective action is applied to production control processes, and the results are evaluated. Reliability then is obtained through control, not change.

Product Flow

Typical steps through which components pass at the supplier plant and into Autonetics are indicated in an accompanying drawing, based on product flow at PSI. Diodes, fabricated at the company's diode and rectifier plant, are brought to a separate 40,000 sq. ft. location where samples are selected to see that they meet Mil specifications. Here diode samples undergo two series of tests, common for all company diodes. One group is short order tests—shock, vibration and temperature cycling. In one test the diode is vibrated for 30 sec., and should shunting of the junction, an anticipated possible failure occur, it appears as shifting of the reverse characteristic viewed on a scope. Top of the diode is repeatedly struck in another test, resulting in a change in the forward characteristic (in the event of failure) because the failure mechanism is a movement of the whisker during shock. If a lot doesn't qualify, it is culled to remove potentially unreliable units. Samples are put through a second series of tests, longer in duration, including 10-day moisture resistance, thermal storage and operation under electrical load. In the moisture resistance test, the diode is subjected to alternate hot and cold cycling. Parts samples which survive this company reliability testing experience field operating failure rates between 0.1 and 0.01% per 1,000 hr. of operation, according to PSI estimates.

Components successfully arriving at this point are available either for sale or for selection as candidates for the Minuteman program. Some of the participating manufacturers, like Motorola, have separate production lines for Minuteman components although, at least in Motorola's case, the same production and process control techniques are applied to all transistor production. Others, like PSI and Fairchild, select Minuteman components from their normal production runs.

Minuteman component candidates then undergo 100% testing including vibration, shock, thermal aging and wa-

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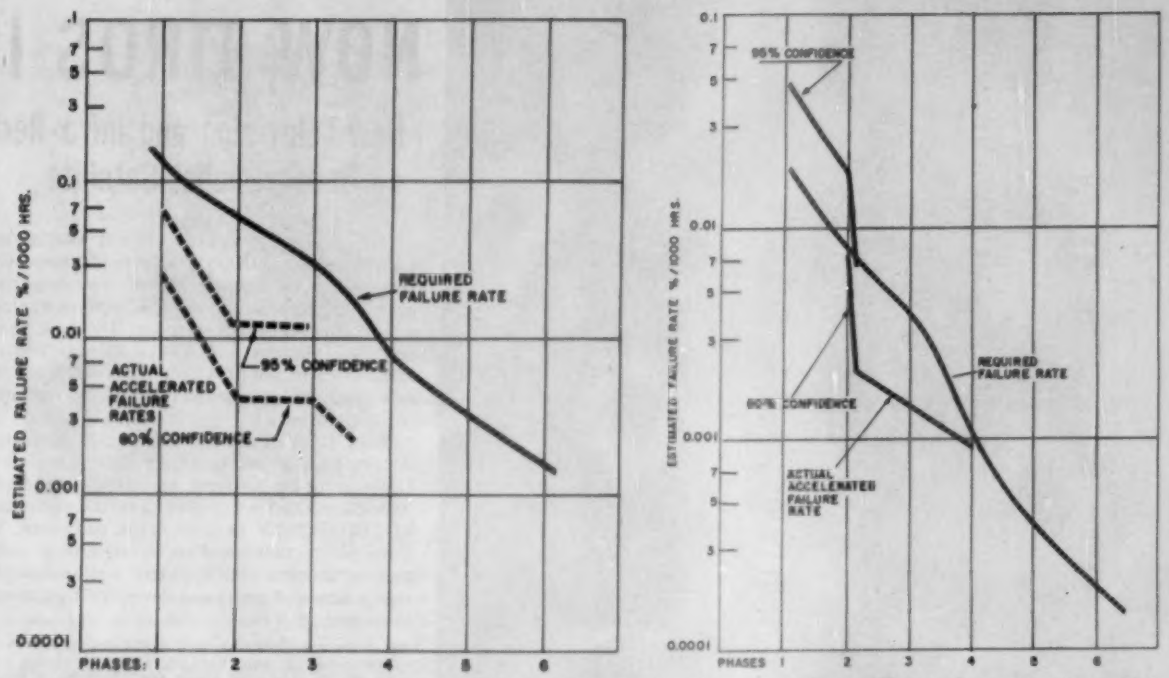

ESTIMATED failure rates of several component types supplied to Autonetics for Minuteman ICBM guidance and control systems. Estimated failure rate of Pacific Semiconductors' computer diode, most widely used component in the system, reached 0.009% per 1,000 hr. of operation based on assumed acceleration factor of 100 (left). Fairchild npn silicon transistors similarly are ahead of goals as of this week for assumed acceleration factor of 75 (right).

ter bomb tests. Completing all tests, components are soldered in special trays for shipping to Autonetics and individual punch cards containing data on electrical characteristics of each component accompany the component trays to Autonetics.

Before shipping to Autonetics, at three points during the course of the program batches of components are removed for a special series of matrix tests which are regarded as key to the program. These tests provide:

- **Failure rate derating curves** to be used as applications data.
- **Autonetics with a means** of following progress of the program in detail.
- **Correlation between actual** component failures in use and under acceleration. When this is known, a small sample can be used to accurately predict failure rate for an entire lot.
- **Parts for failure diagnosis.** This is merely a byproduct.

In matrix tests, samples of components are placed on life racks at different temperatures, voltages, currents and powers above and below rated operating conditions. Chart showing numbers of components operated at these parameters is in matrix form. Number of components is selected to surround optimum operating conditions for the component.

In first matrix an effort is made to determine weaknesses, if any, in the component, and to find failure modes in the component. From results of this first matrix the actual acceleration factor should be found. Second matrix is tested under environmental conditions which Minuteman is expected to encounter and the third is expected to finally demonstrate the failure rate objective. Numbers of components tested at each temperature and power differ within each matrix and from company to company. Fairchild, for example, will test 9,800, 9,300, and 34,100 in three matrices for its npn transistors, and 9,800, 9,300 and 42,600 for pnp transistors, or a total of 114,900 components.

About 75% of the matrix components, Autonetics estimates, will find their way back into the flow of components for the Minuteman assembly.

Component Rejection

At Autonetics components are tested and a small portion are long life tested. Components which fail to pass weekly acceptance tests can be rejected. Similarly, should a batch of components fail to pass another series of acceptance tests 4 months shipments can be rejected. Among others, Autonetics prepares exception by component value curves, exception by amount of change in specified period. The former is a plot indicating the distribution of component values around a rated value. Conceivably, a batch of resistors, for example, which qualify in all respects may display an unusually high percentage whose values group near the upper tolerance limit. This might indicate a potentially unreliable failure condition. Similarly the exception by amount of change plot might indicate variation in tolerance after a period of time heavily in one direction but still within acceptable limits. This, too, might be a danger signal.

A vital feature of the program is failure analysis effort. Each subcontractor maintains a skilled group of professional people—physicists, chemists, metallurgists and engineers—to study causes of component failures. At Fairchild, for example, this group, called the autopsy committee, is composed of representatives from every area within the company. Its function is to track down unusual phenomena or failures that cannot easily be characterized.

The sequence of steps for failure analysis and corrective action at Motorola follows: quality control group receives faulty components and makes preliminary electrical evaluation. The parts are then passed along with failure analysis forms to engineering where components undergo a standard sequence of about two dozen tests, including mechanically opening the unit, subjecting it to chemical, spectrographic and photographic analysis. A form is finally prepared indicating failure mode, symptom and required corrective action.

The close working relationship between Autonetics and its various suppliers is quite unusual. Each supplier must maintain a program plan and sub-

NOW, TIROS II

New Television and Infra-Red Observational Satellite

TIROS II—Improved experimental weather observer—follows TIROS I to provide man with new and more comprehensive views of earth's ever changing weather patterns from its vantage point some 400 miles in space. The new, more definitive pictures and data it gathers and returns to earth are providing a ground work for new giant strides in meteorology and long range weather forecasts.

Tiros II satellite, like Tiros I, was designed, developed and built by RCA's Astro-Electronics Division for the National Aeronautics and Space Administration. It includes all of the equipment of TIROS I—TV cameras, tape recorders, TV transmitters, command receivers, timing mechanisms, beacons and telemetry equipment—plus many new and improved devices. Chief among these are:

New scanning and non-scanning Infra-Red Sensing Devices—Developed by NASA to measure and record the heat radiation of the earth and its cloud cover adding new dimensions to existing weather data.

New Magnetic Orientation Device—a revolutionary advance to capitalize on the effects of the earth's magnetic field on TIROS II and maintain favorable orientation of the sensors over an extended period of time.

New noise suppressor circuits—to help eliminate extraneous noise from TV pictures TIROS II returns to earth.

New miniaturized RF Diplexer—to provide important savings in payload space and weight.

Improved horizon scanners and sun angle sensors—to give better orientation information for more efficient use of satellite photography and data.

Ground stations for TIROS II were designed and developed by RCA. This includes the primary stations at Fort Monmouth, N. J., at the Pacific Missile Range and the back-up stations at Princeton, N. J. and Cape Canaveral, Florida.

Many of these outstanding improvements were designed, developed, tested and incorporated in TIROS II within the short period of time since TIROS I was launched. It is an example of the kind of dynamic capability that is available to you at RCA's Space Center by simply contacting the Marketing Manager, RCA Astro-Electronics Division, Princeton, N. J.

If you are interested in participating in this challenging team effort, contact the Employment Manager, Astro-Electronics Division, Defense Electronic Products, Princeton, New Jersey.

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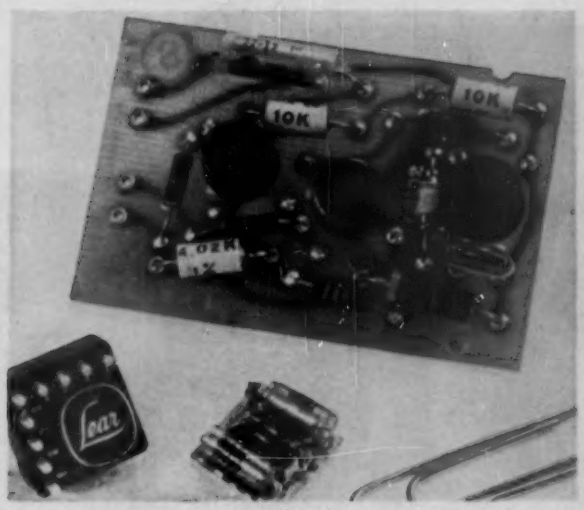
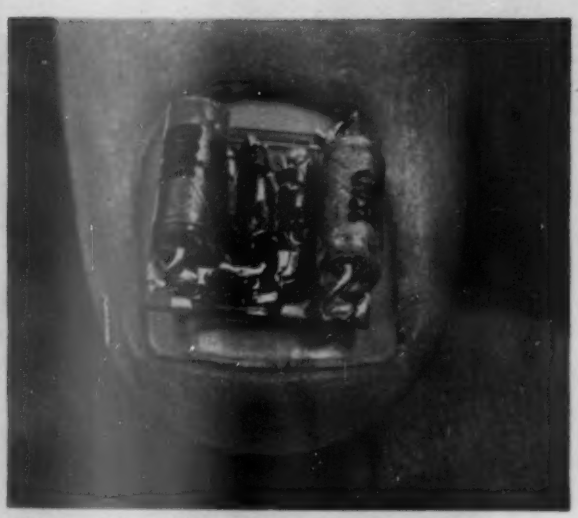




Voltage Amplifier Realizes Size Economy

Microcircuit version of three-stage voltage amplifier achieves considerable size economy as shown before and after encapsulation (left) below original version. Small amplifier operates from 28 v.d.c.; turns out 30 mw., has output impedance of 2,000 ohms and maximum gain of 40. Microcircuit version is fabricated by finely controlled evaporation of film resistors on one side, and small valued capacitors on other side of glass substrate. Diodes and uncased transistors can be inserted in ultrasonically drilled holes of substrate for connection between resistors and capacitors. At right, two 1500 picofarad capacitors and several diodes are shown mounted on substrate of unencased three-stage amplifier. Solid State Physics Laboratory of Lear, Inc., in Los Angeles is responsible for development.

mit periodic reports to Autonetics. Once a month a group of Autonetics administrative and technical people hold what frequently amounts to an all-day technical direction, or TD, meeting at the supplier's plant. At these meetings, reports by personnel from both organizations detail various problems and tasks of the entire program. The exchange is unusually frank. In intervening weeks individual engineers concerned with some specific problem relating to the program pass back and forth between Autonetics and the supplier. All facilities and processes at the supplier's plants are under continual supervision by visiting Autonetics engineers and trained technical personnel maintained by the guidance assembler at each supplier's plant.

An integral part of the program is extensive training and orientation of personnel from production workers through management. Autonetics found production yield increased 18% after a worker orientation and TV presentation program began. At PSI, a status review of the program is presented once a month. Training movies, charts and visual aids are employed.

The program manager reports to the company's management on the program's success, problems, and remaining tasks. This information is passed to the staff in a sequence of meetings depending on the level of interest. Monthly reports to production workers are tied in with foreman's meetings.

As orientation for new employes, a company representative explains the importance of national defense and an Autonetics team details the Minuteman program and how PSI fits into it. A PSI representative then elaborates on his company's participation.

Motorola has prepared several color sound-on-film movies and several series of records used in conjunction with color slides for training and orientation of workers.

Various incentive schemes are also employed. At Fairchild special start-of-week-breakfasts are organized for workers with excellent attendance records.

Radiation, Inc., Builds Bullpup Simulator

Flight characteristics of the air-ground Martin Bullpup missile are incorporated into mission simulator built for Martin-Orlando by Radiation, Inc. Bullpup appears as a blip on the scope; pilot-trainee then attempts to guide the missile to the target at the center of the screen through a control arm. Some problems, such as drift or target bearing change, are programed into the simulator. Readout devices (not shown) automatically display trainee's miss distance at conclusion of each simulated mission.

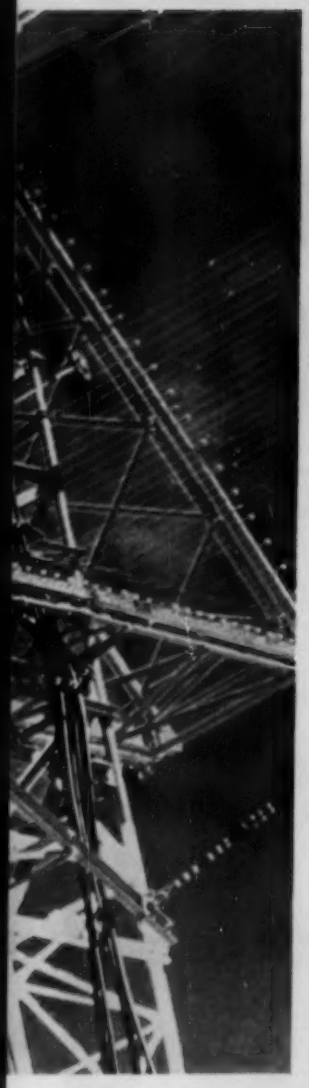
Engineer inspects Styroflex® cable installed on an antenna array at one of Pacific Scatter Communication System stations shown at right.

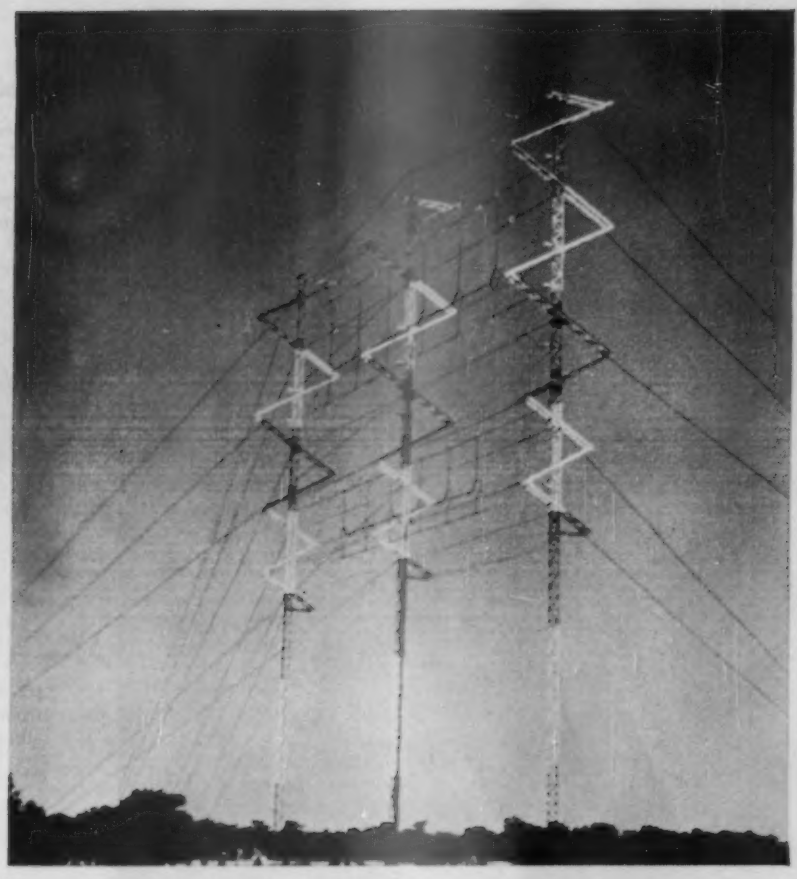
Over 40 miles of *Styroflex® Coaxial Cable* help assure

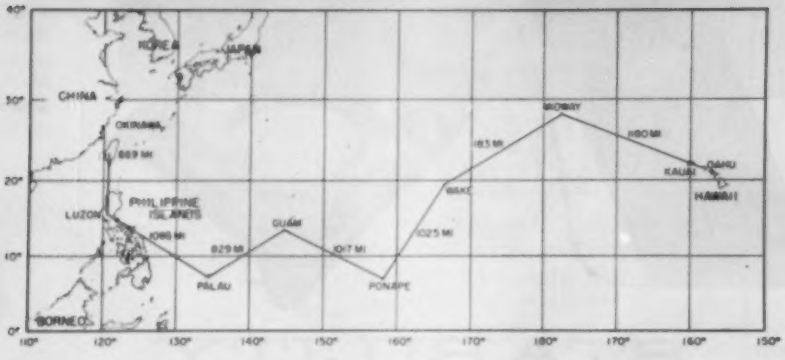
More than 200,000 feet of Styroflex® coaxial cables are in active use as balanced antenna feed lines in the recently completed Pacific Scatter Communication System stretching from the Hawaiian Islands to Okinawa. This trans-Pacific system, one of the largest and most advanced of its kind in the world, uses ionospheric and tropospheric propagation techniques that produce over 99% reliability. An important part of the Strategic Army Communications Network (STARCOM), the system was designed, developed and constructed by Page Communications Engineers, Inc. for the U. S. Army Signal Corps.

Each of the nine stations in the network is equipped with the same major component parts—transmitters, exciters, multiplex terminals and antennas. The cables used in the 200- and 400-foot antenna arrays range from 7/8" jacketed Styroflex® cable to 3 1/8" jacketed Styroflex® cable. About 7,000 feet of 1/2" jacketed Foamflex® cable is also used in the system. The Styroflex® cables were spliced in the field by an inert-gas Heliarc welding process to assure noise-free connections required for successful duplexed antenna operation.

The extremely low inherent noise level and low attenuation of Styroflex®—together with this air-







Pacific Scatter Communication System reliability!

dielectric cable's stable electrical and mechanical properties—especially qualify it for the critical specifications of this STARCOM system. If your system requirements call for a cable with low loss and high reliability, investigate the successful record of Styroflex®!

(Photos courtesy of Page Communications Engineers, Inc.)

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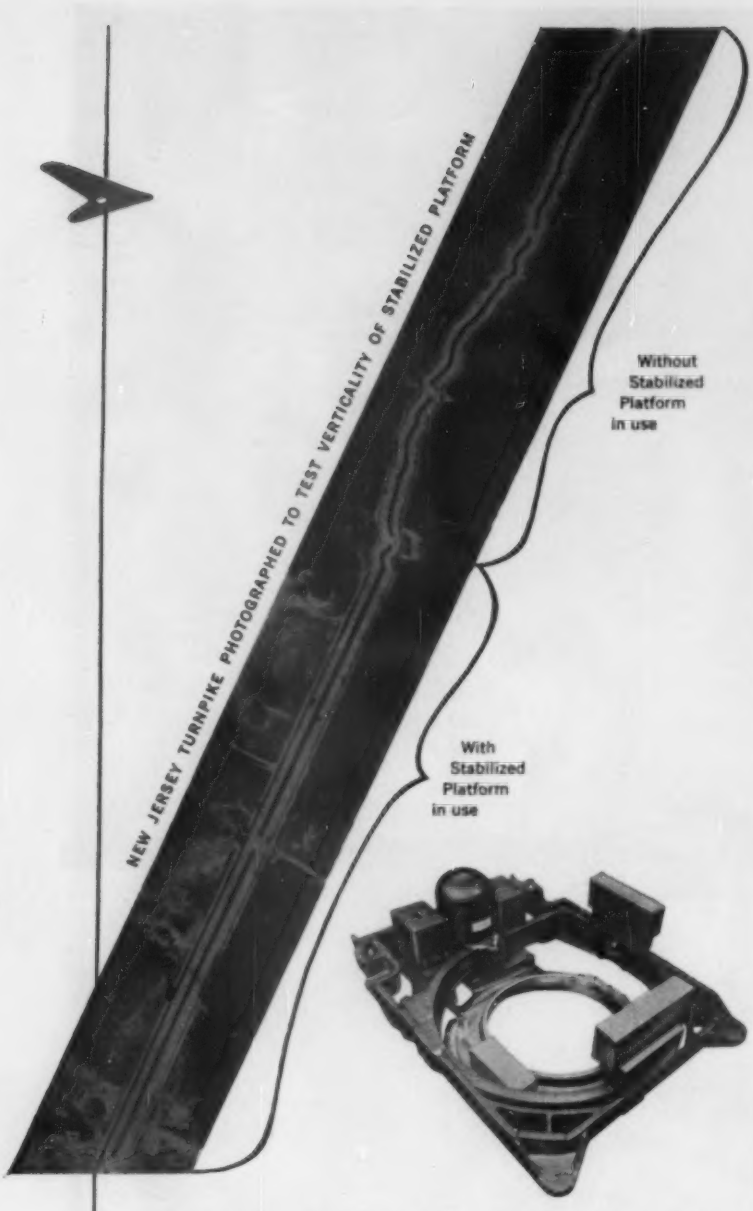
NEW JERSEY TURNPIKE PHOTOGRAPHED TO TEST VERTICALITY OF STABILIZED PLATFORM
Without Stabilized Platform in use
With Stabilized Platform in use

STABILITY

When your problem requires a precision stabilized platform for its solution, then Aeroflex Laboratories can provide a gyro, slave, or inertially stabilized system of proven verticality and reliability, conforming to MIL-I-6181 and MIL-E-5272.

For additional information on Stabilized Platforms for photographic, IR, radar or other unique applications requiring the stabilization of large devices, address inquiries to Dept. SP-6.

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AEROFLEX LABORATORIES

DIVISION

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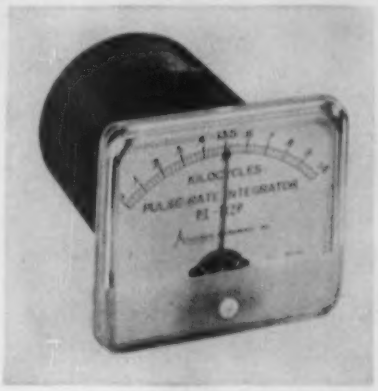
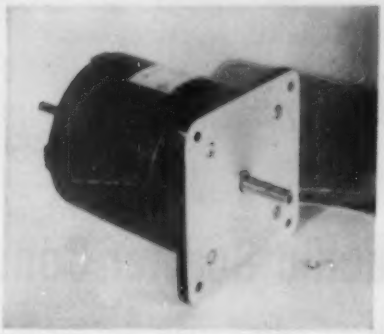
NEW AVIONIC PRODUCTS

• **Pulse rate integrator,** PI-111 and PI-112, designed for monitoring radiation detectors, tachometers, repetition rate pick ups. The frequency deviation integrator has input sensitivity as low as 10 mv. rms., can indicate variations at different center frequencies from 50



cps. to 50 kc., depending on the particular model. For example, one will indicate variations between 380 and 420 cps. The PI-111 measures 3½ in. wide, the 112 is 4½ in. Prices range from $150, with 30 day delivery. Anadex Instruments, Inc., 14734 Arminta St., Van Nuys, Calif.

• **A.C. motors,** 4,500 frame series, includes units providing outputs to 1½ hp. as induction motors, up to 300 in.-oz. stall torque as torque motors and from 1/200 to ¼ hp. as hysteresis synchronous motors. Motors in the

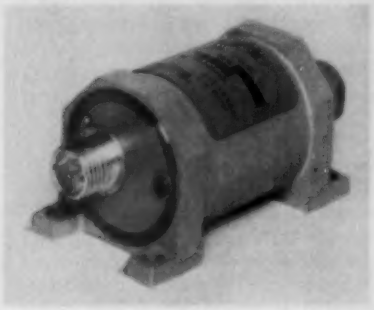


4,500 frame size have outside diameter of 5¾ in. and are available with one, two or three phase inputs, 26 to 230 volts and with frequencies from 25 to 400 cps. Data sheets are available from the manufacturer, IMC Magnetics Corp., Eastern Division, 570 Main St., Westbury, N. Y.

• **Electromechanical chopper,** Model 30, weighs 9 grams, measures 1 in. x ⅜ in. x ⅜ in. and is for use on 6.3 volts, 60 cps. single phase a.c. to mechanically modulate information signals with a

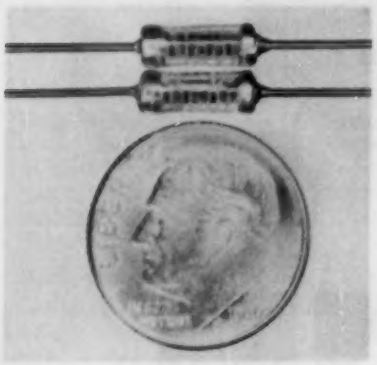
60 cps. modified square wave. It operates from d.c. to 150 cps. in—65 to 100C range. Airpax Electronics, Inc., Cambridge Division, Cambridge, Maryland.

• **D.C. pressure transducer,** P2-3000 series suitable for applications with critical weight limitations. One model, type P2-3076 for pressure ranges up to 5,000 psig, weighs 5 oz. and requires



3 ma. at 28 v.d.c for zero to 5 volt d.c. output. Units measure approximately 3.15 in. in length and have 1 kilohm output impedance. Davstrom-Wiancko Engineering Co., 255 N. Halstead St., Pasadena, Calif.

• **Carbon film resistors,** TI Type CG¼ housed in hermetically sealed hard-glass cases, can dissipate ¼ watt, twice that set by MIL-R-10509C for same dimension package. Resistors are available in values from 24.9 ohms to 82.5



kilohms. A ½ watt unit, designated CG½ can be obtained in values from 24.9 to 18.2 kilohms. Both types are available in 1, 2 or 5% tolerances. Manufacturer: Texas Instruments, Inc., P.O. Box 312, Dallas 21, Tex.

• **Flip flop modules,** HF-2 plug-in unit contains two flip flops capable of speeds up to 5 mc. and interconnection to form shift registers or counters without external gating. The flip flops are compatible with gates made by same firm and single-phased clocked systems operating at speeds up to 3 mc. can be made from the combination of the two. Manufacturer: Abacus, Inc., 3040 Overland Ave., Los Angeles 34, Calif.

SURPRISING!

Exceptional performance characteristics of Servonic's new H-160 high pressure transducer are particularly surprising considering the small size of this potentiometer type instrument. Its 1 by 1½ inch dimensions combine with rugged design and high resolution to make it ideal for military requirements where severe environments are a problem.

Utilizing Servonic's helical bourdon assembly, the H-160 is oil damped to furnish high accuracy and long life, even under vibrations exceeding 35 g. Superior linearity over the temperature range —65° to 275° F is provided in standard construction. Individual performance characteristics have been controlled to provide accuracies of ±1.0% error band in most ranges. The unit can be readily adapted to accommodate a wide range of exotic fluids.

For complete specs on the H-160 and its companion, low cost industrial unit, write for Bulletin S-605.

SERVONIC INSTRUMENTS, INC.

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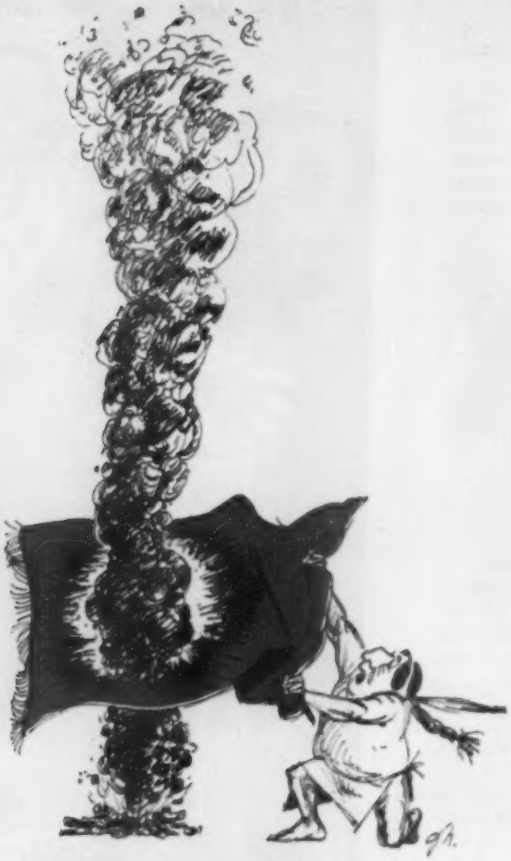
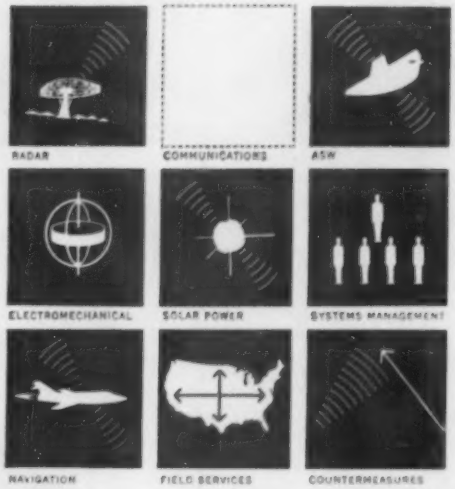
Hoffman



communications problems?

If an enemy should stage a surprise attack against the United States, our survival could depend on fast, reliable communications with command posts around the world. Hoffman has been a leader in the development and production of specialized communications equipment since the early days of World War II. Today, it is making significant contributions to some of the most advanced global communications systems employed by our military forces. With this experience, Hoffman stands ready to offer solutions to your communications problems.



Hoffman / ELECTRONICS CORPORATION

Military Products Division

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Significant developments at Hoffman have created positions for scientists and engineers of high calibre. Please address inquiries to Vice President, Engineering.

Continental Tests Light Turbine Engines

By Barry Tully

Detroit—A front-drive free-turbine engine developing 500 shp. represents Continental Aviation and Engineering Corp.'s entry in the light turbine field.

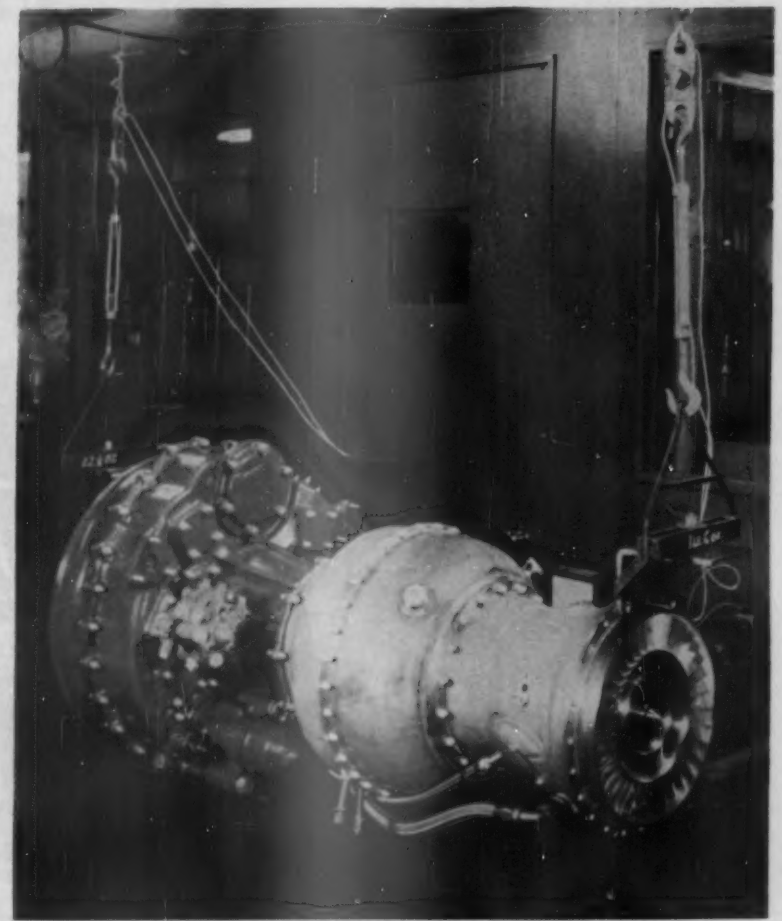
Available in turboprop and turboshaft configurations, Continental's Model 217 turbine (AW Sept. 5, p. 31) is aimed at both military and civil markets. Applications include helicopters, light VTOL aircraft and proposed turboprop business aircraft.

The prototype Model 217 is now undergoing initial test runs at the engineering headquarters of Continental Aviation in Detroit. The 50-hr. qualification test of the engine is slated for April, 1961. Production will be in Toledo, Ohio.

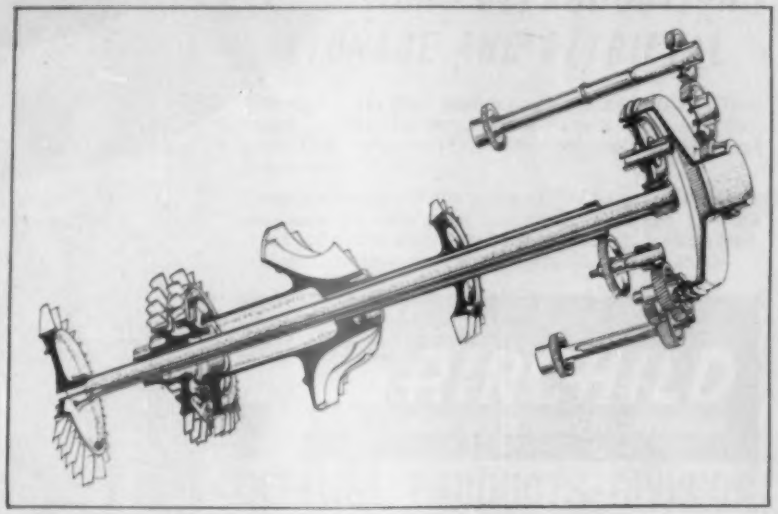
Continental reports that the engine has met its design weight goal of 210 lb. for the turboshaft (turboprop 230 lb.).

Future goals to be met are 500 shp. on takeoff with 0.67 sfc. at sea level standard conditions. Normal rated power at sea level would be 405 shp. At sea level on a 100F day, power would be reduced to 415 shp. on takeoff and 326 shp. normal. At 6,000 ft. on a 95F day takeoff power would fall to 337 shp. and normal rated power to 265 shp.

Continental says that it selected the 500-hp. power rating of the engine after studying the requirements of proposed turboprop business aircraft. This study indicated that a smaller turbine would not provide sufficient hot-day performance and would be limited in stretch potential.



CONTINENTAL'S 500 shp. Model 217 turboshaft engine is suspended for center of gravity and moment of inertia determination. Turboshaft engine dry weight is 210 lb. The rotating components of the front-drive, free-turbine engine (T72-T-2) are depicted below.



Powerplant Possibility

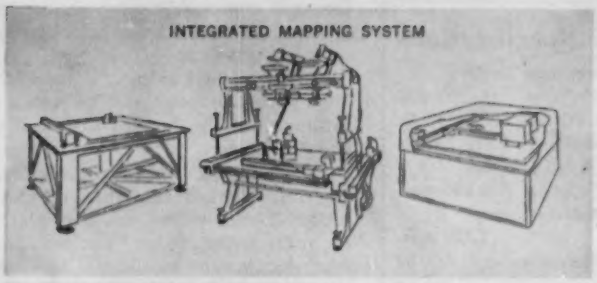
The Model 217 will be mentioned as a powerplant possibility in some proposals for a larger version of the Army's light observation aircraft helicopter program. In this connection, the company-sponsored engine bears the military designation T72-T-2 (turboshaft) (AW Sept. 26, p. 68).

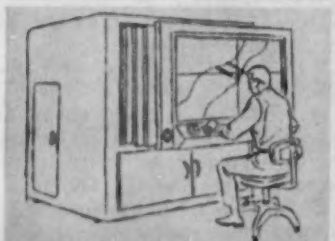
The company says that the turbine's development was not predicated on military sales and it expects commercial sales to carry the project. Price goal, based on volume production, is about $13,000 per unit. Precise cost figures prior to production tooling are difficult to predict; however, Continental is confident that its Toledo production facility will be able to reduce production costs. As an example of this, the company cites the J69 engine which

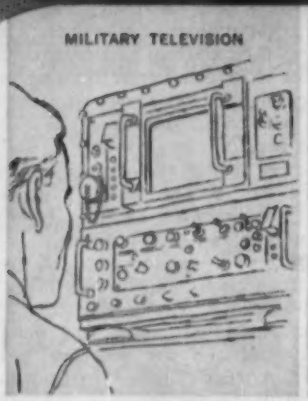
PIONEERS JOIN FORCES...

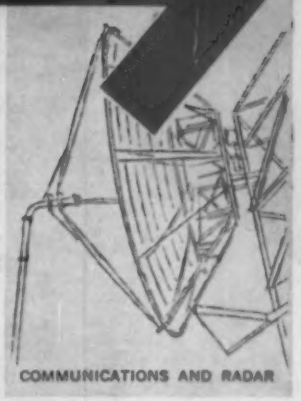
In July of 1960 Mr. Sherman Fairchild and Dr. Allen B. Du Mont, shook hands on the merger of Allen B. Du Mont Laboratories Inc. into Fairchild Camera and Instrument Corp. The Du Mont Military Electronics organization is now a department of the Fairchild Defense Products Division.

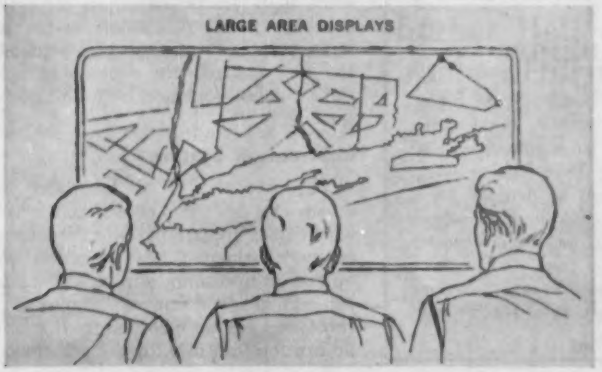
Engineers and scientists are invited to discuss new opportunities presented by continuing growth of the Defense Products Division.











TECHNOLOGICAL FIRSTS FOR FAIRCHILD AND DU MONT

1920—Intra-lens shutter for aerial cameras.

1928—Electrical operation designed into aerial cameras and first fully-automatic cameras.

1931—Practical cathode ray tube developed.

1932—Development of complete oscilloscope.

1937—Long-persistence tubes used in radar displays.

1938—All-electronic television set marketed.

1942—Developed all-electronic lead computing gunsight.

1944—Developed and produced aerial radar reconnaissance recording system.

1945—Developed three-axis rate gyro and servo-controlled stabilization system.

1948—Integrated automatic aerial camera and multi-unit control system. Rapidyne shutter introduced.

1954—Developed reconnaissance camera with self-contained automatic exposure control and five-camera control system.

1960—Developed high acuity aerial reconnaissance system.

1960—Fully automatic tactical photo transmission system.

THE RESULT: INCREASED TECHNOLOGICAL ABILITY FOR FAIRCHILD DEFENSE PRODUCTS DIVISION IN

DATA

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Specifically, Du Mont provides added competence in Television, Communications, Special Radars, Large Area Displays, Fiber Optics and Electronic Test and Ground Support Equipment.

Cross-fertilization of the ideas of Fairchild and Du Mont engineers are developing new system concepts in these areas and further extending Defense Products Division leadership in reconnaissance and surveillance techniques.

FAIRCHILD
CAMERA AND INSTRUMENT CORPORATION

DEFENSE PRODUCTS DIVISION

ROBBINS LANE, SYOSSET, L. I., N. Y.

underwent a unit price reduction from $30,000 to $15,000 within a 2,600-unit production run.

The Model 217 turbine is an original design, unlike the J69 which was built under license from the Turbomeca Marbore turbojet. Continental has close engineering ties with the French company, however, and the 217 bears a resemblance to the Turbomeca Astazou, a connected turbine design.

The free-turbine Model 217 employs a straight-through flow pattern with an axial and a centrifugal compressor, a two-stage gas generator turbine and a single-stage axial power turbine. The turboshaft (Model 217 -5A) and the turboprop (-6A) versions of the engine employ identical aerothermodynamic components. The engines differ only in the speed and location of the output shaft. The turboshaft engine has a 6,000-rpm. output shaft and the prop version a 2,100-rpm. propeller shaft drive.

Gas Generator Section

The gas generator section of the Model 217 consists of a transonic axial compressor stage, a centrifugal compressor, a rotating fuel distributor and the two-stage turbine mounted in a sheet-metal structure housing the stationary aerodynamic components. The axial compressor is machined from a stainless-steel forging. The centrifugal compressor is fabricated from steel forgings and forms part of the main shaft structure to which is attached the annular fuel slinger.

The two-stage axial turbine is connected to the rotor shaft by means of curvic couplings. The turbine wheels are connected by a central bolt serving as the rear shaft of the engine. The main gas generator rotor is supported by a thrust load ball bearing at the compressor end and by a roller bearing at the turbine end. Both bearings and the axial compressor rotor bearing are mounted in hydrodynamically-damped spring suspensions.

The free power turbine is supported by two ball bearings, one of which is hydrodynamically damped to reduce vibration transfer.

A long shaft transfers the torque from the free turbine rotor through the gas generator shaft to the reduction gear at the front of the engine. The reduction gear, designed to handle 600 hp., consists of a high-speed sun gear spline driven from the free turbine drive shaft, three stationary planetary gears and a ring gear which is connected to the output shaft.

On the turboprop version, a two-plane planetary gear is required to secure 2,100 rpm. on the propeller shaft.

At takeoff power, the power turbine will turn at 35,000 rpm. at sea level under standard conditions.

Model 217 Specifications

Takeoff horsepower (sea level/ standard)	500 shp.
Weight (turboshaft)	210 lb.
Weight (turboprop)	230 lb.
Output shaft speed (turboshaft)	6,000 rpm.
Output shaft speed (turboprop)	2,100 rpm.
Specific fuel consumption	0.67

Static Layout

The static layout of the engine follows that of Continental's J69 turbojet. The engine mounts are located on the accessory drive housing. To the rear of the mounts are the compressor and diffuser section, combustor housing and turbine housing. Forward of the mounts, the reduction gear housing is supported from the accessory drive housing by means of four struts in the inlet passage.

Accessories are mounted at the waist of the engine on the rear face of the accessory housing.

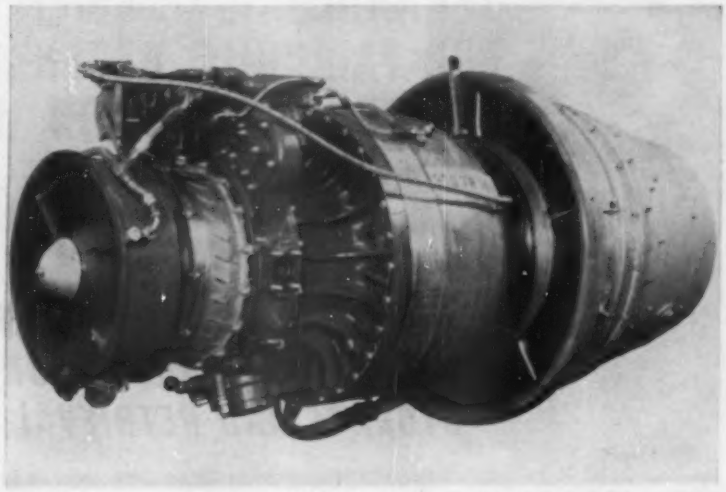
The accessory drive housing also serves as the annular air inlet duct. This housing, the reduction gear diaphragms and the axial compressor housing are magnesium castings; however, aluminum may be substituted at a 25-lb. weight penalty.

The hot section of the engine is inspected by splitting flange joints to expose the combustor housings, turbine inlet nozzles and turbine rotors.

Accessory drives driven by the gas generator section of the engine include a 200-amp d.c. starter-generator, hydraulic pump, oil pump, fuel pump, fuel control and gas generator tachometer. A series of spur gears from the main shaft are employed to drive the accessory pads. A similar mechanical arrangement drives the speed signal to the fuel control, the tachometer and the propeller governor from the power turbine.

Lubrication System

The Model 217 is lubricated by means of a dry sump-type system which will require an external oil tank and oil cooler. Estimated heat rejection and oil flow at maximum output is 650 Btu. per min. at an oil flow of 7.5 gpm. The turboprop engine incorporates the same lubrication system with the addition of

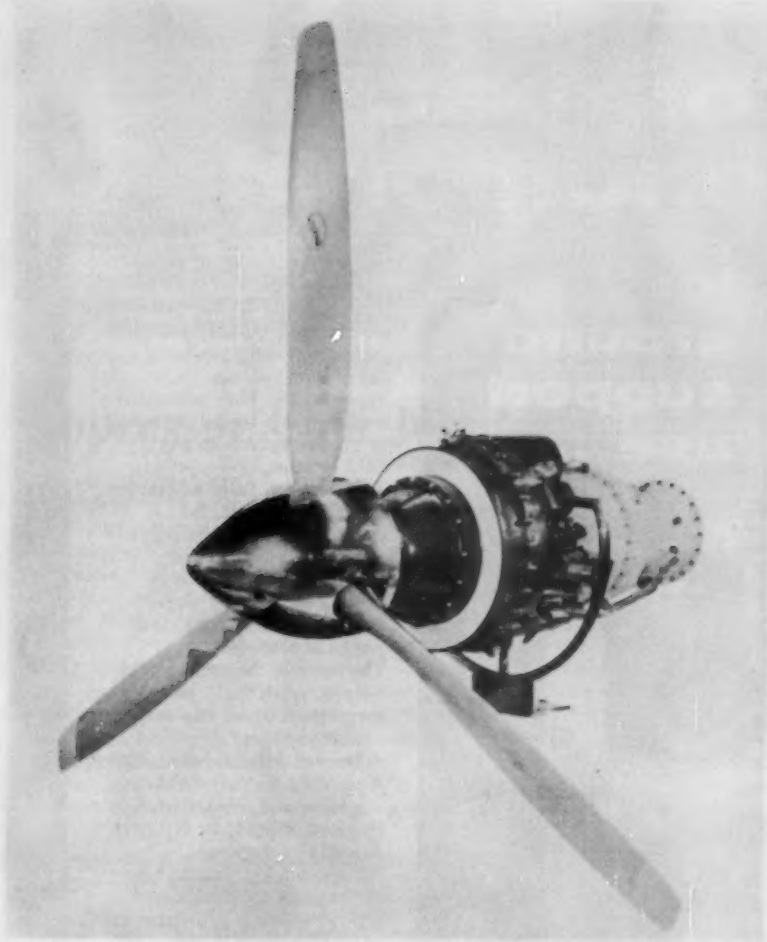


AFT-FAN version of the Continental J69 turbojet is rated at 2,600 lb. of thrust with a .75 sfc. This 480-lb. engine, now in development, is designated the Model 356-16.

Continental J69 Aft-Fan Engines

Continental Aviation & Engineering Corp., in an effort to broaden its jet engine line, is designing a 2,400-lb. thrust turbojet and 2,600-lb. and 4,000-lb. thrust aft-fan engines based on the J69 gas generator. The 2,600-lb. thrust fan engine, designated 356-16, stems from the 1,700-lb. thrust unit powering the Ryan Firebee target missile. The 4,000-lb. thrust aft-fan, designated 356-24, will be designed for a 0.64 sfc. Continental feels that aft-van versions of its axial-centrifugal compressor engines will provide an economical fan engine with just a slight increase in diameter over axial compressor models.

This increased diameter would make the engines most suitable in aft fuselage mountings. The engines, now in the preliminary design stages, await specific military or commercial requirements prior to final development.



MOCKUP shows the turboprop Model 217-6A as it would appear with propeller fitted. Three-bladed prop and spinner mockup was produced by Hartzell Propeller, Inc.

a hydraulic torquemeter and provisions for a hydraulically-controlled propeller.

The fuel system of the engine employs an engine-driven fuel pump, a hydromechanical fuel control and a rotary fuel distributor.

In the helicopter engine, power output is a function of the power turbine speed and also of the collective pitch setting.

Gas generator speed is varied by the power turbine governor to maintain constant turbine speed as the pilot changes collective pitch settings.

Single Power Lever

A single power lever is employed. On the turboprop, power output is controlled by establishing gas generator speed.

The free turbine speed is controlled by the propeller governor.

Thus, both power and prop control levels are required.

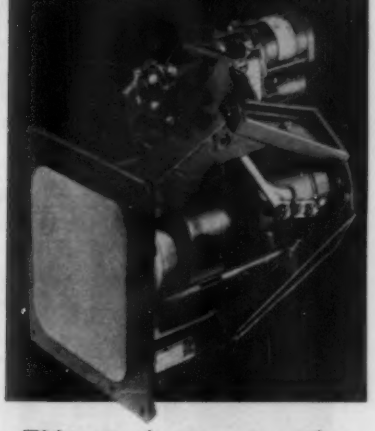
A hot air bleed from the compressor section, activated manually by the pilot, will afford engine inlet anti-icing.

In regard to growth potential, Continental says that 600 hp. is an easy step requiring only changes in aerodynamic profiles to increase mass flow. Ultimate growth envisioned for the engine, without increasing its physical size, is 850 hp. and sfc. of 0.64. This version of the 217 is well into the future, however, and Continental says that if a firm requirement is established, a 50-hr. preliminary flight rating test can be completed on the 600-hp. engine in July, 1961.

Hughes Helicopter Crashes During Test

Hughes YHO-2HU two-place helicopter being evaluated by U. S. Army crashed last week in a dive from low altitude, injuring test pilot Gene Moore. Moore said cockpit became too warm and he decided to land; last altimeter reading he recalled was 40 ft. Hughes engineers are investigating possibility of carbon monoxide poisoning. Helicopter is military version of Hughes Model 269A (AW Apr. 4, p. 88).

Another
electromechanical
problem solved by
AiResearch



This ram air scoop is another example of AiResearch's ability to design and integrate structural and electromechanical systems for control functions.

Through its use, air is provided for emergency cabin pressurization and the cooling of electronic components. The unit is composed of a retractable aluminum ram air scoop, extended and withdrawn by a 400 cycle rotary actuator, a self-contained 350 watt heating element and an integral check valve.

The most experienced company in the development and production of control systems for airborne and ground use, AiResearch has the ideal facilities and know-how to handle problems concerning electromechanical systems and components of all types for aircraft, ground handling, ground support and missile systems.

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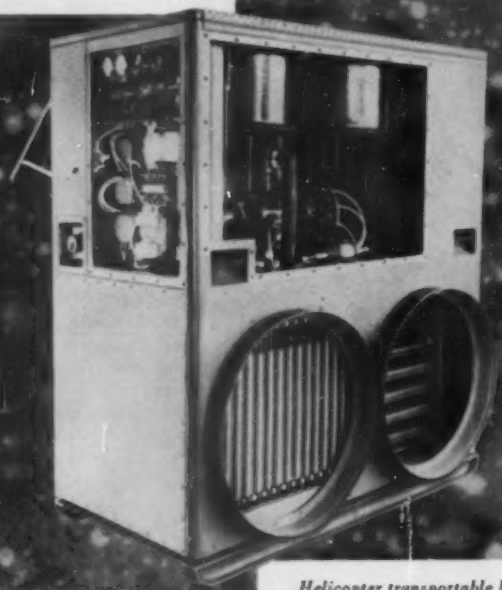
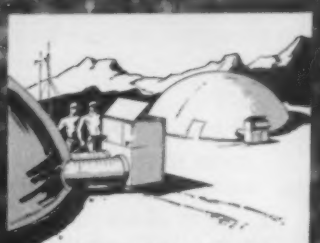
AiResearch Manufacturing Division
Los Angeles 45, California

Compact air conditioning

for ground support use...

Trailer mounted refrigeration unit, 5 tons capacity





Inflatable shelter refrigeration unit, 7½ tons capacity (unit shown above)

Helicopter transportable hut refrigeration unit, 1½ tons capacity

AIRESEARCH 400 cycle ac Freon ground air conditioners are the most reliable and compact systems produced for ground cooling applications. They are easily transportable by helicopter or ground vehicle to any field location.

The compact, fully automatic unit shown at left, for example, measures 5x5x2 ft, weighs only 550 lb and provides 7½ to 10 tons of cooling on a 125°F day. It also provides 90,000 Btu per hour heating.

The heart of the system is a simple centrifugal Freon compressor which has only *one* moving part.

A hermetically sealed unit, it operates virtually without vibration and is unaffected by either attitude or oil level.

Essentially the same AiResearch air conditioning system used in today's jet airliners, these lightweight units have more than 500,000 hours of proven dependability.

Built to withstand rough handling in the field and operate dependably under the most severe weather conditions, rugged air conditioners of this same basic design are available, or can be built to provide from fractional tonnage up to any capacity of ground cooling desired.

• A brochure describing AiResearch ground air conditioning systems may be obtained by writing to Environmental Controls Project, Los Angeles Division.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

PORTABLE system reduces noise levels of jet engine runup 10-25 db. at 250-ft. distance. Manufacturer is General Acoustics Corp.

Suppressor Cuts Jet Runup Noise

Portable jet runup noise suppression system consisting of noise control units for jet engine intake and exhaust which will reduce noise levels 10 to 25 decibels at distances of 250 ft. are now available from General Acoustics Corp., Los Angeles, for domestic or foreign airfields.

The intake unit of the system consists of a structure of highly absorptive steel sound panels mounted on a wheeled undercarriage. No tie-down is required for full-power runup. The intake suppressor enclosure also eliminates the hazard of personnel being drawn into the engine intake opening.

The exhaust unit is adjustable to accommodate various aircraft engine nacelles or different heights. High-temperature steel augmentor-diffuser elements are included in the unit, which efficiently reduces noise levels 20 to 25 db. at 250 ft. without creating back pressure on the exhaust flow. A turning-vane elbow and vertical stack deflect exhaust gases skyward, protecting runup surface areas as well as ramp personnel and vehicles.

Positioning of the exhaust suppressor is accomplished with a forward towing arrangement. Either jet engine mounts or ramp fittings can be used for tie-down.

The company also is studying projects involving high-intensity noise produced during missile and space vehicle launchings from surface and silo-type facilities. Sound and thermal surveys indicate that many potential malfunctions are produced during launchings. Structural failures from sonic fatigue and the effects of high-intensity noise levels in missile and space programs are being studied by General Acoustics.

Knowledge gained from noise surveys and field testing is being applied by the company to future systems for ducted fan engines and other powerplants.

USAF F-105s Fly Florida-California Under Automatic Control

Two USAF-Republic F-105 fighter-bombers are shown making remote-controlled flights from Florida to California, with the pilots handling the controls only during takeoff and landing. The F-105s completed each of two 1,600-mi. legs in 3½ hr.

Electronic module being inserted into reactor beam port for irradiation.

UNIVERSITY-INDUSTRY COOPERATION The Bendix Systems Division is developing electronic equipment that resists damage from nuclear radiation. This program is being carried out with the aid of experiments conducted in the nuclear reactor of our next-door neighbor, The University of Michigan. Bendix staff members also participate in the University's teaching program, while faculty members play important roles in Bendix projects. In addition, nearly one out of every three Bendix engineers is taking advanced work at the University. This university-industry cooperation offers new kinds of career opportunities for better engineers and scientists at Ann Arbor.

BENDIX SYSTEMS DIVISION
ANN ARBOR, MICHIGAN

THE Bendix CORPORATION

BS 75 Turbofan Testing Program Detailed

By John Tunstall

London—Bristol-Siddeley plans to begin bench-testing its BS 75 turbofan engine in January, 1962, and to offer the 7,550-lb.-thrust powerplant for installation 12 months later, a timetable that keeps development of the engine well ahead of development of the two airframes it has been selected to power.

When the turbofan is installed on the BAC P. 107 (AW July 18, p. 41) and Avro 771 (AW Sept. 5, p. 43) medium-range transports, it will incorporate an annular vaporizing combustion system instead of the original cannular design. The change resulted from operational comparisons of the Olympus and Sapphire turbojets—both relatively high-pressure engines.

In outlining new details of its BS 75 design and test program for AVIATION WEEK, Bristol-Siddeley reported that basic type-testing of the engine should take place about December, 1963. Full certification should follow in early 1964, far in advance of the deadline set by the two airframe manufacturers.

Overhaul Costs

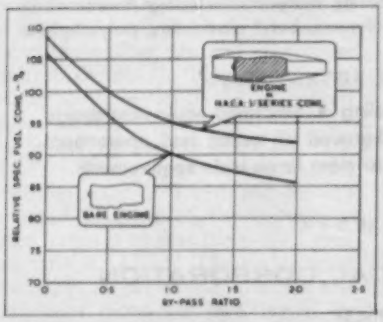
Bristol is offering to guarantee maximum overhaul costs for the first two years of operation. The guarantee includes cost of premature parts replacement and modifications and covers cost of overhaul manhours in excess of 700.

Guaranteed minimum lives even for the hot parts is to be 2,000 hr. For all other major components it is to be 4,000 hr.

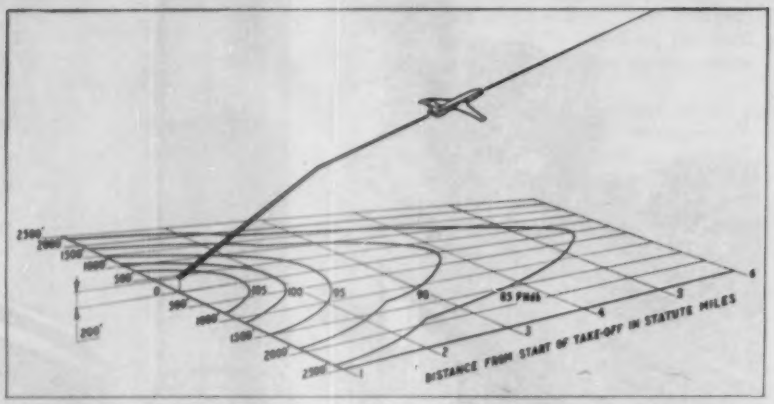
Bristol says this is the first time such comprehensive overhaul guarantees have been offered by the company on an engine entering civil service without any military application or government aid.

This commercial policy is believed to be in line with proposals for the only other radically new engine similarly guaranteed—the Rolls-Royce RB 141.

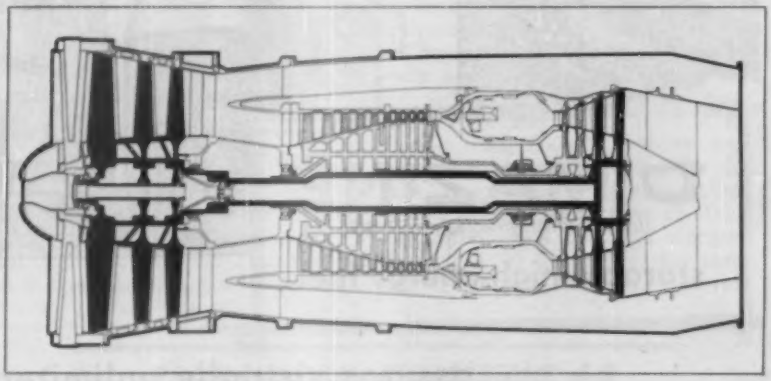
Access to the Sapphire annular combustion data has proved one of the immediate benefits of the merger between the former Armstrong Siddeley Engine Co., makers of the Sapphire, and Bristol Aero Engines, Ltd. Virtually all British turbojets other than those from Armstrong Siddeley used the cannular system.



EFFECT of nacelle drag on cruise specific fuel consumption is shown.



TAKEOFF noise of a BAC 107 powered by two BS 75 ducted fan engines is shown above.



BRISTOL Siddeley BS 75 ducted fan engine is illustrated above.

Orderly Flow Pattern

Main advantage Bristol Siddeley sees in the annular geometry stems from the more orderly flow pattern through the system which prolongs its life. A number of premature cannular failures in two important British turbojets indicates that the annular system is specially beneficial on engines with high compression ratios.

Bristol Siddeley emphasizes that although it will enjoy the superior characteristics of an engine designed to exploit the turbofan configuration, it will be able to utilize extensively, and without much scaling, the major rotor and compressor elements proven in existing gas turbines.

In respect of size, number of stages, stress and temperature parameters, the turbines of the BS 75 are basically similar to the Proteus 705 turboprop. The same manufacturing and quality control techniques will be utilized. Turbine blades and stators will be of vacuum-cast cobalt alloy, a specification introduced advantageously in the later marks of Proteus engine.

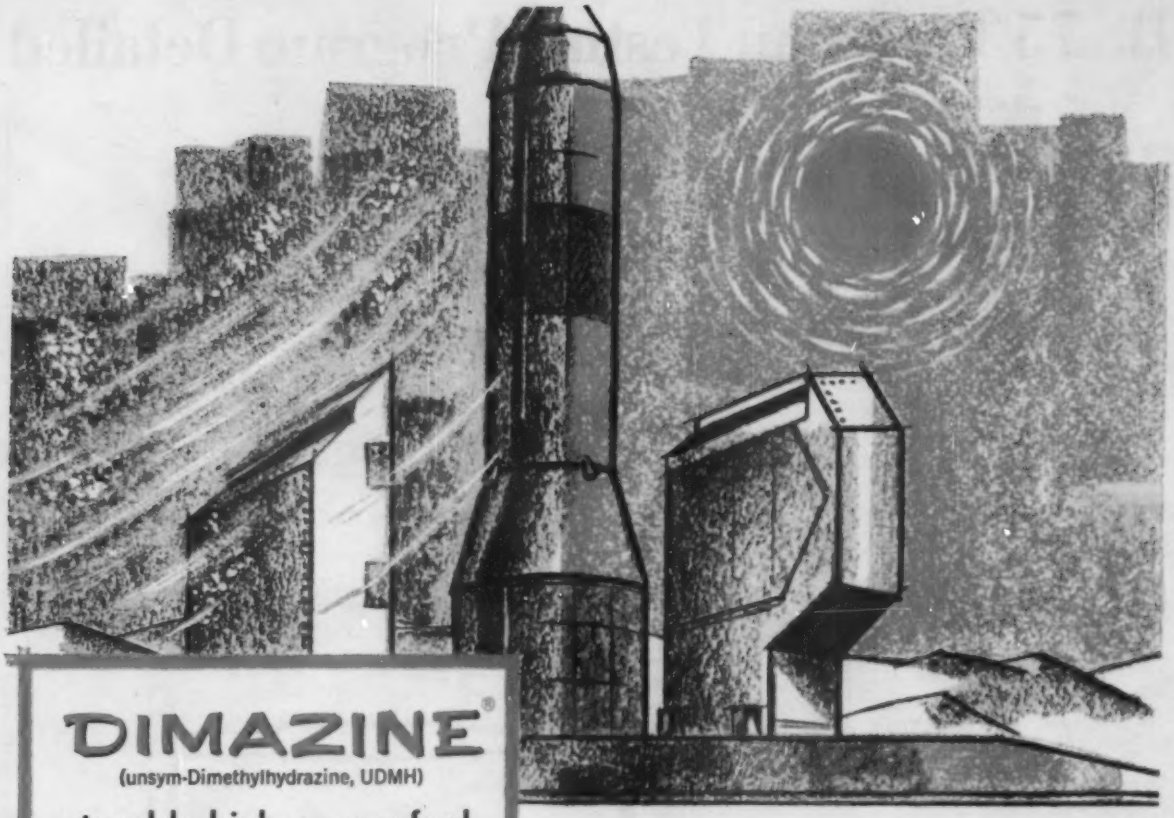
Main difference between the turbines arises mainly because of the higher pressure ratio used in the BS 75. Consequently its first stages have a smaller blade height than the Proteus stages and the last stages a greater blade height giving the BS 75 annulus a higher flair angle.

As blade stress depends on the speed (rpm.) squared multiplied by the area of the annulus and blade taper, optimization of blade taper has enabled the selection of rpm. and annulus area to maintain stresses at Proteus levels.

Fan Stages

The fan stages are aerodynamically similar to the first three compressor stages of the Olympus Mk.201 although scaled down in recognition of the lower air mass flow of the BS 75 which is 20% less than the Olympus.

The compressor of the BS 75 retains



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U. S. Exports of Aircraft, Parts, Accessories

Item	August 1960		Cumulative totals January-August 1960	
	Number	Value ($1,000)	Number	Value ($1,000)
Aircraft, parts, and accessories, total	.....	97,262	.....	936,022
Commercial and civilian aircraft, total	183	46,642	1,579	373,381
Aircraft 3,000 lb. and over empty airframe weight:				
Cargo transports, commercial, new	.....	.....	.....	.....
Passenger transports, commercial, new:				
3,000-14,999 lb. empty airframe weight	3	344	37	4,259
15,000-29,000 lb. empty airframe weight	3	2,201	7	5,945
30,000 lb. and over empty airframe weight	6	40,441	68	328,432
Rotary wing aircraft, commercial, new	1	324	4	1,312
Commercial and civilian aircraft, used and rebuilt, including converted	10	1,328	85	13,030
Aircraft under 3,000 lb. empty airframe weight:				
Utility, commercial and civilian, new:				
3 places and under	31	253	254	2,018
4 places and over	79	1,489	778	13,552
Rotary wing, commercial, new	1	69	51	2,694
Commercial and civilian aircraft, used and rebuilt, including converted	30	204	294	2,109
Commercial and civilian aircraft, new, n.e.c. (all empty airframe weights)	.....	.....	3	22
Aircraft engines, reciprocating, new air-cooled under 400 hp [1]	75	152	1,017	2,499
Aircraft engines, reciprocating, used and rebuilt	105	387	980	6,345
Aircraft components, parts, and accessories, n.e.c. [2]	.....	50,101	.....	563,648

Source: Foreign Trade Division, Bureau of the Census.
[1] Air-cooled reciprocating engines, new, 400 hp. and over are included in "Aircraft components, parts, and accessories n.e.c."
[2] Includes military aircraft.

most features of the seven-stage compressor of the Orpheus turbojet. But in the interests of efficiency the stage load factor has been lowered and three additional stages added, making the compression ratio 7:1 as against the 5:1 of the Orpheus.

Fundamentally useful in the development of the BS 75 concept has been the Olympus program started in 1950 using high rpm., high mass flows, low cycle temperatures and jet velocities and culminating in the addition of the zero stage of the Olympus which increased the static rating by 20%.

Out of the BS 53 turbofan program which began bench test 12 months ago and made its first flight in November (AW Dec. 5, p. 33) has come confirmation of the mechanical arrangement and handling of large mass flows in a ducted fan without gearing the fan rotor. Without the need to minimize the gyroscopic couples from the rotor system, Bristol Siddeley has avoided the use of an intermediate shaft bearing as used in the contrarotating fan and compressor shafts in the BS 53. The fan and compressor shafts in the BS 53 are entirely independent.

The BS 75 has the high fan ratio of 1.75:1. The pressure ratio across the three fan stages is 1.85:1 and the fan mounted in front of the compressor supercharges it so that the over-all pressure ratio is 12.95:1. The engine mass flow is 195 lb. per second. The fan and compressor rotors are each driven by two-stage turbines, the maximum shaft speed being 14,500 rpm.

Terms of the Bristol Siddeley guarantees on overhaul vary with the arrangements adopted. With operator overhaul, the company will guarantee a stated figure as the maximum cost per hour of engine parts replaced at overhaul, scrapped in line maintenance, and the cost of any mandatory modification associated with safety. The cost-per-hour figure will be based on the total hours run by all engines in the operator's fleet.

Alternatively the company offers a comprehensive overhaul service available either at its factory or overseas bases. The guarantee then takes the form of an agreed charge for aircraft hours flown by all engines in the operator's fleet. In this case the guarantee applies to all engine parts and accessories.

Bristol Siddeley will also offer an overhaul-exchange service.

When the initial two-year service expires, the company will introduce a substitute form of service in which, should parts become defective prematurely, credits will be issued against the cost of replacement.

These credits will be based on minimum warranted lives for components assigned on the basis of Proteus data, the Proteus being one of the first engines to reach 2,000 hr. between overhaul. Current component lives for the entire Proteus compressor rotor system, turbine disks, last two stages of blades and stators, main cases and accessory drives is 7,000 hr. and for the main bearings and the hot parts—the first

PROBLEMATICAL RECREATIONS 44

From the equation $(x + 1)(x^2 + 1)(x^3 + 1) = 30x^3$, find the real values of x by means of a quadratic only. *—Ladies' Diary, 1764*

The lowly terminal in a printed circuit gets the prime attention it deserves from our U. S. Engineering Co. division. They have designed one with a funnel-shaped base that can be swaged and soldered without stressing the circuit right up off the board. A USECO Distributor is near you.

ANSWER TO LAST WEEK'S PROBLEM: Let the length equal 15" equal b, the first velocity along b per minute equal c, a + b be the length for the first velocity to be infinite, and let x equal the decrease of b in t minutes. Then the velocity equals $c - a^2/(a + x)^2$ and t equals $x(a + x)^2/ca^2$. Further computations will yield the desired answer $t = 26.43$ minutes.

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two blade and stator stages and the flame tubes—the life is 4,000 hr. In no case has an ultimate life yet been established.

Bristol Siddeley proposes to start the BS 75 with 2,000 hr. warranted minimum lives for the main bearings and hot parts, and 4,000 hr. for all other major components. The company expects to eventually treble this rating.

The company aims to start the engine at 500 hr. overhaul by 1965. The 2,000 hr. overhaul rating is anticipated after only a quarter of a million flight engine hours as against the 300,000 hr. logged by the Proteus.

Engine Costs

The line maintenance costs for the engine have been estimated at not more than five man minutes per engine hour and material costs of 28 cents per fleet engine hour.

The rig program which has been in progress since June will involve separate testing of the compressor, fan turbine, turbine, combustion system and full-scale thrust reverser on individual rigs. The program will also include use of a water analogy rig and a compressor entry and bypass air flow model.

Using temperatures no higher than those used in the Proteus but with the high fan (bypass) ratio of 1.75:1 Bristol Siddeley has managed to drop the fuel consumption to 0.76 lb. per lb. thrust per hour (typical cruise conditions of Mach 0.75 cruise at 30,000 ft.) the static sea level consumption being as low as 0.508 lb. per lb. thrust per hour.

Sea level static consumption figure for the engine is in fact only half that of the successful NATO single-spool turbojet Orpheus BOr.12 which has a comparable static thrust of 6,800 lb. This engine has specific weight of 6 lb. thrust per pound compared with the BS 75 rating of 5-lb. thrust per pound and a frontal diameter of 32.4 in. compared with the 33.4 in. for the BS 75.

BS Claims Supported

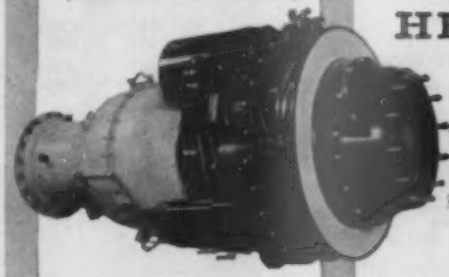
These comparisons of a turbojet and an optimized turbofan tend to illustrate the Bristol Siddeley claim that the advantages of high-ratio turbofans do not entail a serious weight penalty, even when using modest over-all pressure ratios and conservative cycle temperatures.

They also tend to show how small is the frontal area fan penalty.

The specific characteristics of the engine could have been substantially further enhanced if higher values of these two parameters were used. But the temperature was chosen in the interests of long life and the fact that a short-haul aircraft spends a relatively long time at the takeoff rating. The same fuel consumptions of the BS 75 could

LOW-COST TURBINE POWER

T72-T-2
TURBOSHAFT ENGINE
(CONTINENTAL MODEL 217-5A)



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Continental's broad experience in the gas turbine field is being utilized to the maximum in the T72-T-2 program, to provide advanced powerplants at the lowest cost per horsepower of any comparable American turbines. . . . Availability and complete qualification are geared to the Army's L.O.A. programming requirements. This versatile 500 HP turboshaft engine and its turboprop companion (Model 217-6A) also feature "designed-in" growth potential for higher performance ratings with no sacrifice of low specific fuel consumption (0.67) and engine weights of only 210 and 230 lbs. respectively. . . . A bright future is forecast for the T72 and other 217 series turbines, not only for military but commercial applications as well.

WRITE FOR DESCRIPTIVE BULLETIN AND INSTALLATION OUTLINES

CONTINENTAL AVIATION & ENGINEERING CORPORATION
12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

WEST COAST SALES OFFICES: 18747 SHERMAN WAY, RESEDA, CALIFORNIA

Shipments of Civilian Aircraft, Engines

Item		1960 September	Cumulative totals Jan.-Sept. 1960
Complete aircraft, total airframe weight	1,000 lb	2,232.4	22,100.8
By weight of plane:			
Under 3,000 lb. airframe weight	do	402.1	6,045.3
3,000 lb. airframe weight and over	do	1,830.3	16,063.5
By number of places:			
1- and 2- place	do	385.4	5,600.8
3- and 5- place	do		
over 5-place	do	1,847.0	16,500.0
By total rated horsepower, all engines:			
Under 100 hp	do	303.5	4,729.1
100-399 hp	do		
400 hp. and over	do	1,928.9	17,379.7
Aircraft engines:			
Reciprocating	Number	864	8,251
Gas turbine	do	(D)	(D)
Aircraft engines, total horsepower:			
Reciprocating	1,000 hp	180.8	1,741.3
Gas turbine	do	(D)	(D)
Complete aircraft	Number	427	6,119
By weight of plane:			
Under 3,000 lb. airframe weight	do	376	5,743
3,000 lb. airframe weight and over	do	51	376
By number of places:			
1- and 2- place	do	370	5,584
3- and 5- place	do		
Over 5-place	do	57	535
By total rated horsepower, all engines:			
Under 100 hp	do	322	5,072
100-399 hp	do		
400 hp. and over	do	105	1,047
Value of shipments of complete aircraft and parts, total	$1,000	118,606	1,073,942
Aircraft, total	do	108,410	988,954
Under 3,000 lb. airframe weight	do	7,358	106,144
3,000 lb. airframe weight and over	do	101,052	882,710
Aircraft parts	do	10,196	85,088
Value of shipments of aircraft engines and parts, total	do	13,958	124,274
Aircraft engines:			
Reciprocating	do	2,379	21,181
Gas turbine	do	(D)	(D)
Engine parts	do	11,188	103,123
Unfilled orders (planes 3,000 lb. airframe weight and over)	Number	538	

Source: Industry Division, Bureau of the Census.
D—Withheld to avoid disclosing figures for individual companies.

have been approached with a lower fan ratio, higher over-all compression ratio, and a higher noise level. But Bristol Siddeley maintains this layout would have required more stages, more complexity and a weight increase.

Over-all, Bristol Siddeley insists that high bypass ratios approaching two to one show a 10% performance improvement over engines with ratios nearer one to one when both use the same cycle temperature.

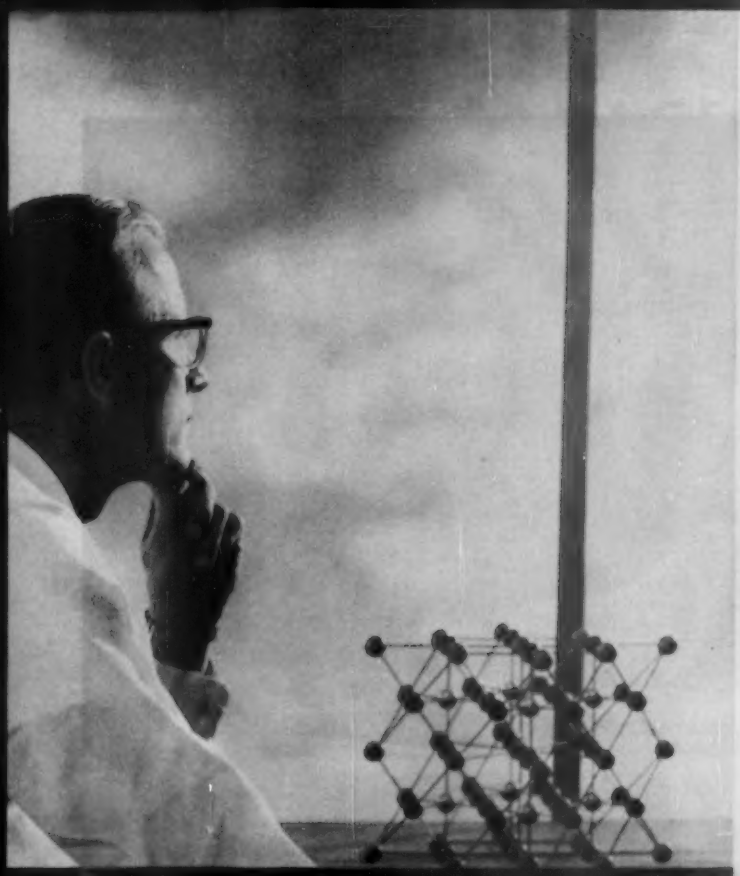
Objections

Objections in British engine circles to high fan ratios were based on rapid increase in pod drag due to the increase in fan diameter. It was considered that with the above ratios on the order of one to one the increase in pod drag canceled the gains due to propulsion efficiency.

British pod data was initially scarce due to the adoption of a buried engine philosophy. Now more recent calculations by Bristol Siddeley using nacelles of NASA–Series 1 cowl geometry and subsonic drag data for bodies of revolution from Royal Aeronautical Society data sheets are claimed to demolish the adverse drag rise argument. Nacelle drag curves show substantial net gain with increasing fan ratio up to two to one.

Bristol calculations also show that the advantages of high ratio over lower ratio turbofans is maintained at part load and low altitudes.

From noise considerations the low jet velocities of the BS 75 lead to a decrease of 15 perceived noise decibels compared with a turbojet. Air intake noise levels assume the same value as the jet representing an increase of about 3 PN decibels. The reduction in jet noise of a one to one turbofan according to Bristol calculations, is about 10 PN decibels. Other engine details include maximum turbine entry temperature 1,220K, maximum cruise thrust 2,530 lb.



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DOWN-TO-EARTH cost orientation at Motorola begins with disciplined research applied to *creative ideas* and, progressively, pervades every stage of development, assembly, and final production. Ultimately it is reflected in lower field maintenance and support costs consistent with the desired level of reliable performance. This acute awareness of *total* cost versus initial cost, sharpened by more than thirty years of competitive experience and commercial success, is characteristic of Motorola's complete military electronics capability in terms of systems, equipment, and Solid State components.

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- Navigation Systems & Equipment
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Texas Aerospace Companies Urged To Form Bloc to Gain Contracts

Dallas, Tex.—Aviation companies in the Dallas-Ft. Worth area should form a bloc for the purpose of developing and retaining a greater portion of aerospace business volume in this community, according to Ling-Temco Electronics President James J. Ling.

The bloc should utilize the talent available locally in forming teams to bid on aerospace contracts, rather than seek alliances with firms outside the state. It should also attempt to retain a larger volume of subcontracting in the community and it should increase its political efforts in an attempt to bring a greater share of defense business to Texas, Ling stated.

It appears, he told members of the Texas section of the Institute of the Aeronautical Sciences, that Texas certainly has not gotten the aerospace business it could have gotten, in the past few years, and in the final analysis this seems to mean that some people in other parts of the U.S. have been using political pressure more effectively than the people of Texas.

Ling stated that the future of the aerospace industry appeared "very cloudy" and that this atmosphere has caused investment bankers to consider that the industry is in a period of financial crisis.

Pointing up the local situation, he noted that in the past two years the aircraft industry in the Dallas-Ft. Worth area has suffered heavily as a result of cutbacks due to transition from airframe to space development and budget restrictions.

In 1958, employment at Chance Vought and Temco totaled about 24,000. In 1960 it declined to 13,000.

Chance Vought-Temco defense backlogs were approximately $778 million in 1958 but these slid to about $275 million in 1960 and sales of these companies have gone down from approximately $452 million in 1958 to $260 million in 1960.

An important effect of these declines has been pressures on management by members of their boards allied with other industries to set the companies in new directions to offset these losses. In many cases management has to devote considerable effort that could have been expended in solving its problems to fighting off what it considered ill-advised moves, Ling noted.

Effect on key personnel has also been harmful, he added.

Morale has suffered because of lessening of confidence in their companies' futures.

Stock option plans, which have been a useful tool in retaining key personnel, have lost much of their value because stocks have declined below the value originally set under the initial optional plan, he said.

Ling stated that he thought that the local industries, acting as a bloc, could effectively halt the drain in business by doing a better job collectively of educating their customers in the services and government of their capabilities than they can individually and that by providing them with a picture of the team capabilities of the area present a stronger case for obtaining more business.

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Senior Officers Cut From Flying Status

Washington—Navy has put all its pilot-admirals on non-flying status and Air Force has excused 237 of its 312 pilot-generals from meeting flight proficiency requirements in moves designed to counter congressional displeasure with the number of senior officers on flight status.

These moves also help the services to meet pilot quota cuts ordered by Congress. Senior Air Force officer affected is Chief of Staff Gen. Thomas D. White. The 237 officers in this category, all with more than 20 years as pilots and over 45 years old, will continue to draw flight pay.

Navy interpreted congressional intent as calling for a cut in proficiency flying by senior officers and put all 94 of its pilot-admirals on non-flying status between January and June. Of 798 pilot captains, the Navy already has a substantial number in the non-flying category, and by June 30, about 450 will have been excused from flying.

Air Force wil have 118 generals remaining on full proficiency flying status after June 30. By the beginning of Fiscal 1962, there will be 577 colonels excused from the requirement, while 2,660 will remain in full flight status.

Navy faces a pilot shortage with two additional aircraft carriers operating in the fleet in an alert ordered last summer in the face of the congressional cuts. Active duty requests are being accepted from reserve ensigns, lieutenants (jg) and lieutenants. Ceiling imposed by Congress and apportioned by the Department of Defense will be reached by removing from flying status commanders and lieutenant commanders who have been passed over for promotion twice.

Army, with only nine generals in 6,500 pilots and with proportionately fewer colonels and lieutenant colonels than the other flying services, is in a quandary on how to make its cut.

In a smaller way, the Coast Guard has a pilot shortage. Coast Guard officials say they need 30 more pilots in this fiscal year to replace reserves who have retired. Pilots in the first two pay grades returning to inactive duty from other services are being offered regular commissions in the Coast Guard, and several are reported to have accepted. A requirement for about 20 pilots a year will exist for three or four years.

Air Force is paring pilot lists in lower ranks by removing pilots from flight status who were selected by a general board which finished its work Nov. 1. A list of 3,799 was prepared, and from this list cuts will be made to get under the ceiling set by the Department of Defense.

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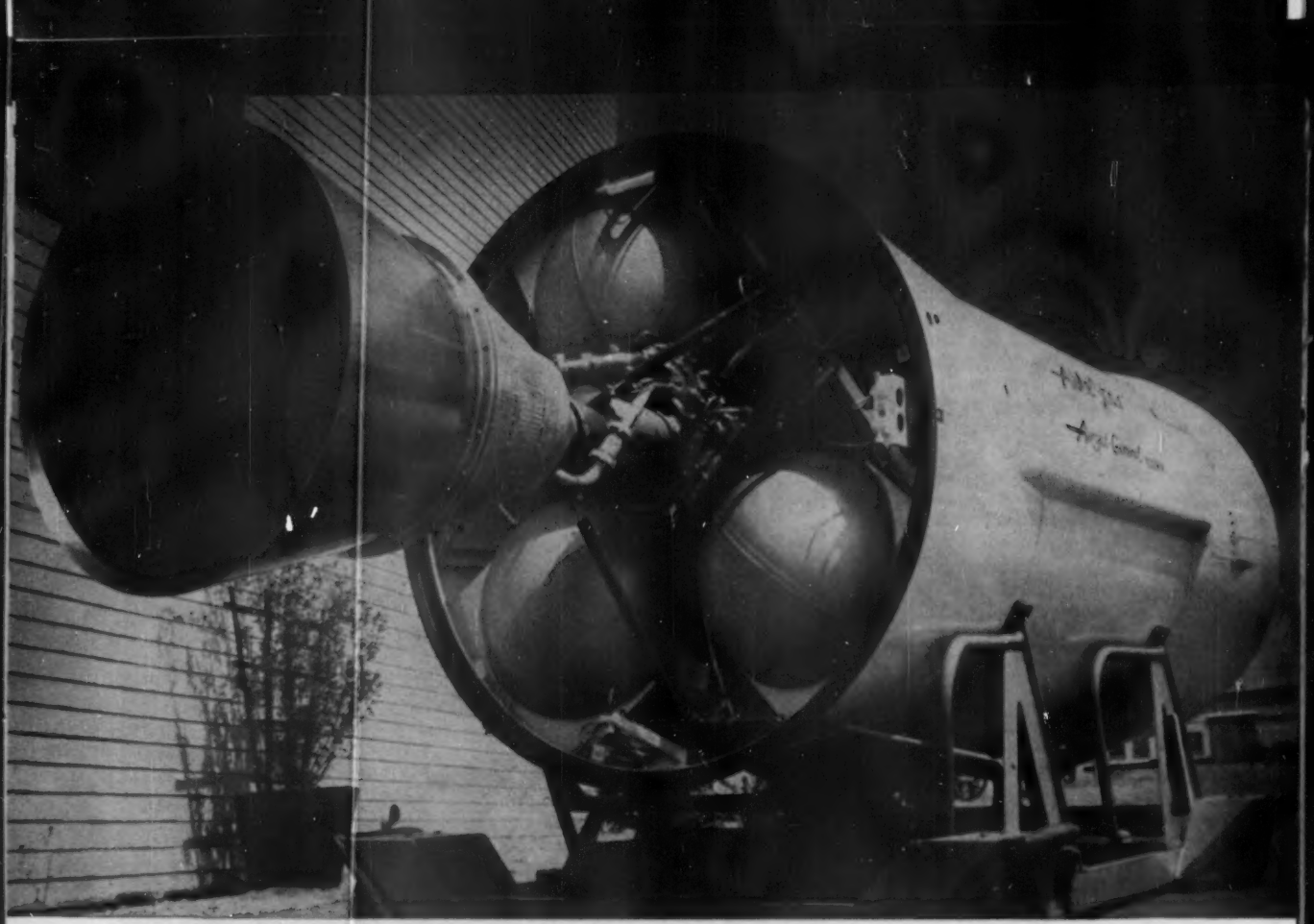

Aerojet General's restartable Ablestar upper stage uses three titanium pressure bottles for a weight-savings of 60 pounds. The nozzle extension is also titanium.

How Titanium pressure bottles reduce missile weight

Trend based on metal's high performance, fabricability and immediate availability suggests retrofit applications

The swing to light-weight, high-strength titanium metal for pressure bottles in the current generation of liquid-fueled missiles provides conclusive proof of the design advantages and reliability inherent in titanium construction. (See box score)

This state-of-the-art report, prepared by Titanium Metals Corporation of America, outlines performance, price and fabrication histories of the Ti-6A1-4V grade as attested to by those who know the metal best—the firms that realize its benefits most.

Titanium's performance history may thus chart a path to important weight reductions in space probes, as well as in orbital vehicles and manned missiles. Titanium pressure bottles are now solving weight and reliability problems in complex pressurization, restart, actuation and stabilization devices.

Suggested also by this trend are a number of retrofit applications of titanium pressure bottles in aircraft... cockpit pressurization, ejection, and other pneumatically controlled and actuated systems.

HIGH STRENGTH-TO-WEIGHT RATIO The metal's most important attribute can be summed up in a few words ... *titanium is 44% lighter than steel at the same strength.* In addition it has...

RELIABILITY AT CRYOGENIC TEMPERATURES Unlike many metals, titanium retains good mechanical properties as the temperature drops. Titanium pressure bottles have shown high strength, ductility, impact resistance and low notch sensitivity at temperatures below *minus* 300F and working pressures up 9,000 psig. *There is no evidence of a single failure in service.*

MECHANICAL PROPERTIES According to Mr. Abe Hurlich, Supervisor, Materials Research Group, Convair-Astronautics Div., General Dynamics Corp., Ti-6A1-4V vessels display the following mechanical properties (note especially retention of ductility):

BOX SCORE ON TITANIUM PRESSURE BOTTLES

60 pounds saved in Ablestar First successful rocket engine to be restarted in space uses three spherical titanium pressure bottles to hold helium at 4,350 psig for the pressure feed system. According to Aerojet Spacecraft Division, Aerojet General Corporation, designers and builders of Ablestar, the titanium (Ti-6A1-4V) pressure bottles saved a total of 60 pounds over steel.

Titan losing 150 pounds Martin Company reports that it is in the process of switching from aluminum to titanium (Ti-6A1-4V) bottles and is saving 150 pounds in each missile! Four spherical bottles, containing helium, furnish pressure for fuel and LOX systems. Two are used in each stage and are contained inside the LOX tank. In addition to high strength-to-weight ratio and cryogenic properties, Martin listed the "availability" of titanium pressure bottles as a factor in the change.

High performance dictates titanium in Agena Lockheed Aircraft Corporation reports that titanium's high performance, as well as its light weight, was important in the choice of Ti-6A1-4V alloy for spherical helium pressure bottles used in Agena "A", satellite for the "Discoverer" program. An average of 8 pounds per bottle were saved, according to Lockheed engineers. From three to five bottles, depending on the program, are used as reservoirs for the cold gas reaction jets in the stabilizing system.

325 pounds saved in X-15 Four Ti-6A1-4V titanium bottles that store helium at 3,800 psig are used in the X-15 "manned missile," for a weight-savings of 325 pounds over the original Inconel X bottles. A 96" x 14" cylindrical bottle operating at −300F, pressure feeds LOX and ammonia to the engine through a reducing valve. Three spherical bottles pressure-feed hydrogen peroxide to the engine, pneumatically control propellant system valves, and purge the engine for restarts.

Pioneered on Atlas; saves 129 pounds per bottle The titanium pressure bottle was developed to a practical reality on Convair-Astronautics' Atlas. The original stainless steel sphere weighed 205 pounds. The Ti-6A1-4V titanium sphere, heat-treated to 160,000 psi, weighs 75 pounds! Design burst pressure is 5,000 psig at ambient temperature. Actual burst pressures at −320F have been consistently at 9,000 psig and higher.

Mechanical properties: Ti-6A1-4V pressure vessels

	TEST TEMPERATURE	
	70 F	minus 320 F
Yield strength (0.2% offset)	137,000 psi	229,000 psi
Tensile strength	156,000 psi	236,000 psi
Elongation	16%	11%
Reduction in area	52%	36%
V-Notch Charpy impact energy*	17.5 ft-lb	10.0 ft-lb

*Double width, half-thickness specimen with one-half the standard depth notch.

CORROSION RESISTANCE Titanium's well-known resistance to corrosion is another reason for the metal's growing history of reliability under extreme environmental conditions.

FABRICABILITY—WHAT THE FABRICATORS SAY Most current pressure bottles are being made of Ti-6A1-4V, an alloy heat-treatable to 160,000 psi minimum (on a strength/weight basis, this is equal to steel at 280,000 to 300,000 psi). Construction usually consists of hemispherical forgings machined to precise contours, girth welded and heat treated.

Here are reports from fabricators who helped develop the titanium pressure bottle.

Airite Division of the Electrada Corporation, Los Angeles, California, says, "Titanium can be forged and machined as accurately as steel. We are easily obtaining surface finish of 100 microinches and holding contour and wall thickness to plus or minus 0.005 inches."

Menasco Manufacturing, Burbank, California, reports, "We prefer to use it. Titanium is now as reliable as any other metal and has probably a lower rate of reject. After good fabrication procedures are established, old wive's tales are soon dispelled."

AVAILABILITY AND LOWERING COST The development phase for titanium pressure bottles is now over. Fabricators are producing them on a production line basis. The titanium industry can easily produce the Ti-6A1-4V grade required for the solid and liquid fueled programs in design or development, with capacity now in place. Lead-times are generally short, with TMCA warehousing large stocks of the alloy in Toronto, Ohio and Los Angeles for 24-hour shipment.

Prices of the Ti-6A1-4V grade and fabrication costs have diminished steadily: Metal costs have declined 62.4% since 1955; unit price of the titanium pressure vessels employed in the Atlas has dropped 30% since their first use; a rocket case fabricator recently quoted the steel-titanium price differential at 15%, with the titanium case weighing about 40% less than the steel version.

With materials and fabrication costs amounting to only 13% of the total price of any missile system, designers are growing reluctant to concede quality in the actual vehicle. Titanium, accordingly, suggests serious consideration *today*.

HOW TO USE TMCA INFORMATION RESOURCES If you are now fighting a weight bogey on an assembly that requires structural strength at temperatures between minus 320F to plus 1,000F, while retaining corrosion immunity . . . or if you need information on titanium fabrication . . . missiles applications . . . competent fabricators . . . a letter to TMCA's Technical Service Department would probably go a long way to solving your problems. Why not write today?

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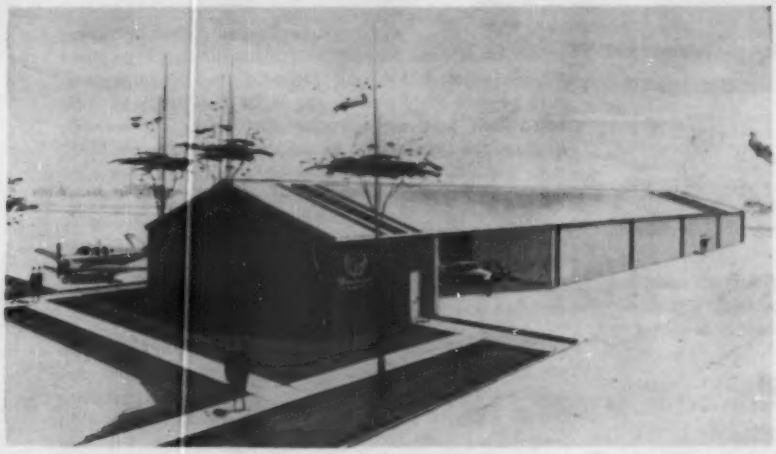
BEECH AIRCRAFT shows its 1961 line at the Wichita factory. In foreground is Super 18 twin, with new picture window in cabin.

Beech Packages Dealer Sales Facilities

By Erwin J. Bulban



T-HANGAR designed by Beech and steel companies (above) will house 10 light twin Baron business planes and costs about $32,221 with a 10% down payment. Below, is drawing of the Beech "C" facility which requires an investment of $100,000 on the part of the dealer. Plan provides a structure costing about $58,500, with a down payment of 25%.

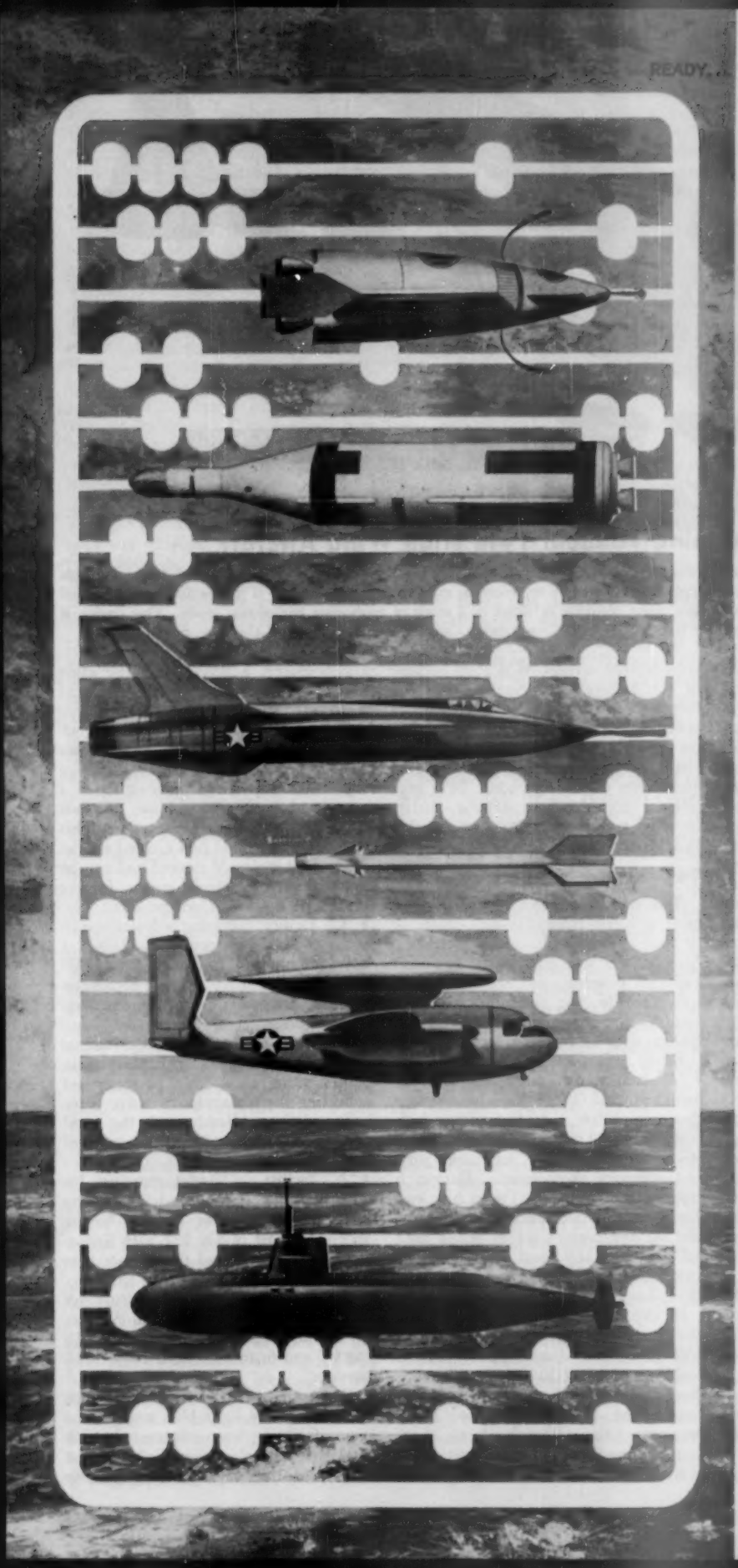
Wichita, Kan.—Prospective business aircraft dealers can order a complete sales and service facility out of a catalog, utilize a ready-made finance plan to pay for it and in 60 to 90 days turn the key to open the business and start operations under a novel package program developed by Beech Aircraft Corp. Detailed package plan includes:

- **Buildings,** complete with furnished offices, customer lounge, parts stock and showroom.
- **New Beech** demonstrator.
- **Dealer's stock** of spare parts, shop tools, stockroom fixtures and other necessary equipment.
- **A business plan** developed by the factory for use as a guide in running and developing the new operation, including a five-year cost analysis.
- **Factory services** in business management, financing, training of sales and service personnel, marketing analyses and other aids.

Package Size

The new dealer also has the choice of deciding what size package he wishes to take, depending upon the potential market in the area he plans to locate. He will be able to start his new business with a cash investment of either $50,000, $75,000 or $100,000.

"Operation Turn Key" is based on the business aircraft manufacturer's conviction that to achieve sales goals reflecting the industry's growth pattern —which indicates a doubling of dollar volumes in the next five years—will re-



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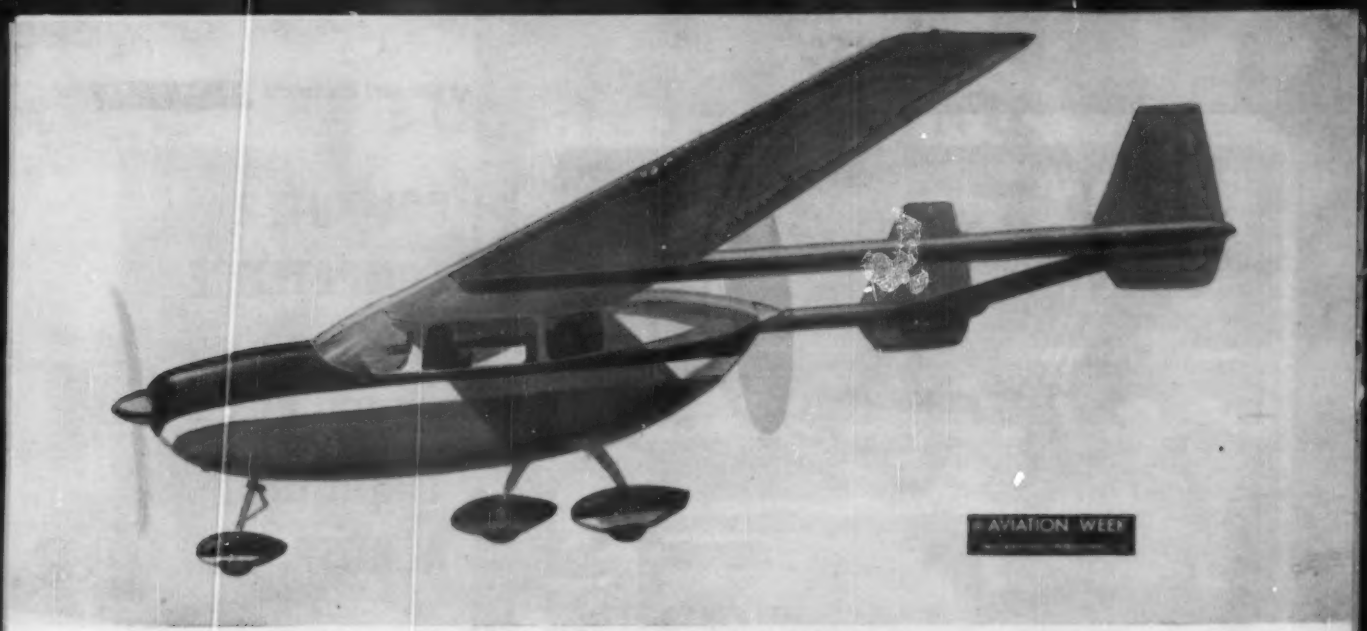


Cessna Designing Tandem Twin High Wing Aircraft

Aviation Week artist's conception depicts Cessna Aircraft Co.'s light twin four-place high-wing aircraft, scheduled to be available in mid-1962 (AW Nov. 14, p. 32). This conception is believed to represent an early stage in the design. It is expected that the actual prototype, scheduled to fly in January, will show some revisions in detail as a result of continuing engineering study. One engine is mounted in nose and the other in the rear of the fuselage. The twin tail is supported on booms aft of the wing trailing edges.

quire that it encourage a rapid, almost explosive, development of sales and service facilities.

To meet increasing competition from other manufacturers and to accommodate its own market penetration programs, Beech sees the need for increasing its present dealer organization by some 200 new representatives in the next three years. This is the way to bring the dealers closer than they now are to the customer, and to hit the competition harder by placing facilities at many locations where now either Cessna and/or Piper are having free rein. It also places representation at some locations where no competition now operates but where market analysis indicates a definite potential exists.

Vice president-marketing Wyman Henry told AVIATION WEEK there is a "gold-mine" in service business waiting to be tapped by the company, because there are places where a good volume of service to Beech owners is being handled by an "outside" operator who doesn't even have a stake in a franchise in the company. "This situation is going to change and some of these fellows are going to have competition before Santa Claus comes around again," the Beech executive said.

Turn Key was developed by Beech in cooperation with several major steel companies on design, fabrication and financing of the facilities with the goal of reducing the decision-making processes a new dealer would have to handle in getting started, freeing him of the necessity for getting involved in building and furnishing details.

Actually, the program is providing considerable savings to dealers because of the factory's participation and the fact that such a program provides a potential of considerable business, based on standardized construction, to the steel companies. Indications are that final prices came down some 30% over original considerations as the parties involved worked out the most feasible and economical designs.

Two Companies Selected

Two steel companies apparently have been selected from the half-dozen or so that entered bids on the facilities. Armco Steel will handle the low and high-cost programs and Stran Steel Co. will provide the buildings in the medium cost range, plus the T-hangars that go with all of the programs.

Briefly, the packages comprise:

• **"A" facility**, requiring a dealer investment of $50,000. This provides a clear-span 100-ft. x 60-ft. building with 60-ft. door and space for 1,000 sq. ft. of office, customer lounge, rest room, parts and accessory show room. Hangar is capable of housing two Travel Airs, two Bonanzas and two Debonairs. Erected cost on the dealer's lot or leased land will be $28,160 and this can be financed with the steel company with 20% down over five years.

If expansion becomes desirable, a 40-ft. extension can be added onto the "A" facility, providing a 100-ft. x 100-ft. building with 1,600 sq. ft. of office space. Building then will be able to hangar one Queen Air, two Twin-Bonanzas, two Travel Airs, three Bonanzas and three Debonairs. Price of the addition to the basic structure is approximately $20,000 with the same down payment and time payment features.

• **"B" facility**, requiring a dealer investment of $75,000. This encompasses an 80-ft. x 100-ft. clear-span building with 1,600 sq. ft. of office space and capable of handling one Super 18, four Bonanzas and four Debonairs. This facility will cost $41,648 erected on the dealer's lot or leased ground and can be financed with the steel company for five years with a 25% down payment.

• **"C" facility**, requiring a dealer investment of $100,000, provides a 100-ft. x 120-ft. clear-span building with 2,400 sq. ft. of office space. It can accommodate one Super 18, one Queen Air, one Twin-Bonanza, two Travel Airs, five Bonanzas and five Debonairs. Erected cost will be $58,500 with steel companies taking 25% down payment and collecting the remainder over five years.

In addition, Beech and the steel companies have developed two types of T-hangar facilities:

• **"E" facility**, a 10-unit structure for aircraft of the Beech Model 55 Baron light-twin category or smaller, having an erected cost of $32,221 with financing of 10% down and the balance over five years.

• **"F" facility**, a 10-unit structure for aircraft of Super 18 or Queen Air size or smaller, which will cost $85,918 erected and financed with a 20% down payment.

Buildings are colored metal, with white roofs and light blue walls. The main facilities are constructed with brick-stone and glass trim. Color scheme is part of Beech program to develop

definite company identification at all airports where its facilities are located. On roofs of new facilities and on present stations, it is promoting painting of a pattern of orange-red, white and blue stripes to make the Beech dealer facility readily visible from the air.

Prices given for these facilities are based on those estimated on labor costs and materials handling to a location in Topeka, Kan., and will naturally vary some depending upon local conditions, Beech points out. For example, it is estimated that these facilities erected in the New York area may cost about 19% higher than the par figure for the same installation in Topeka; in San Antonio, Tex., it is believed that the cost may be approximately 6% lower than par.

Prices also include installation of lighting and heating facilities.

To complete the above packages, which only comprise the buildings and necessary utilities, the dealer can order from catalogs, office equipment and furniture, stockroom and display fixtures and all standard and specialized shop tools and equipment needed to give him a completely ready-to-go plant. Beech estimates that the "A" facility dealer can completely furnish the basic package at a cost of approximately $4,100, of which $2,100 can be financed through supply houses handling this equipment; the remainder, comprising specialized Beech tools would be purchased from the factory.

If the "A" facility dealer also gets the 40-ft. addition to his plant, his investment to completely furnish that layout would cost about $4,500 of which approximately $2,400 can be financed through supply houses. "B" facility will require an additional investment of $4,500, of which $2,400 can be financed; "C" facility will cost approximately $7,500 to furnish completely of which about $3,800 can be financed through the various supply houses in these lines. National supply houses handling furniture, fixture and standard tools and equipment will furnish these items for a down payment of 10% and take the balance over 10 to 20 months, Beech notes.

The manufacturer provides significant business management backup to support the new dealer to ensure that he doesn't make costly mistakes. In preparation now is a detailed business practices manual, compiled as a result of a survey of 20 Beech dealers. If the dealer follows this book, Beech says, he is virtually assured of developing a successful business, and so detailed is the plan that he should know the goals and how close he is to meeting them. Spelled out are accounting practices, spare parts requirement and how this business should grow, income available from fuel sales—just about every facet of the operation. Constant factory market surveys will keep him informed of all potential business in the area, both aircraft and service. Several factory programs have been developed for dealers and their sales and service personnel. Company announced at its distributor-dealer meeting (AW Dec. 5, p. 109) that it will pay transportation and per diem expenses plus $100 weekly salary costs for any dealer that sends his personnel to the factory schools, provided that they have been full-time aircraft salesmen and associated with the dealer at least 90 days.

Of course the dealer is not completely free in selecting his spot—like any chain, the company will survey the area to see if the potential warrants putting a dealer in to serve it.

Company's dealer scouting program includes getting potential candidates from current distributors, contacting local chambers of commerce, contacting good salesmen in other industries and screening applicants who query the factory.

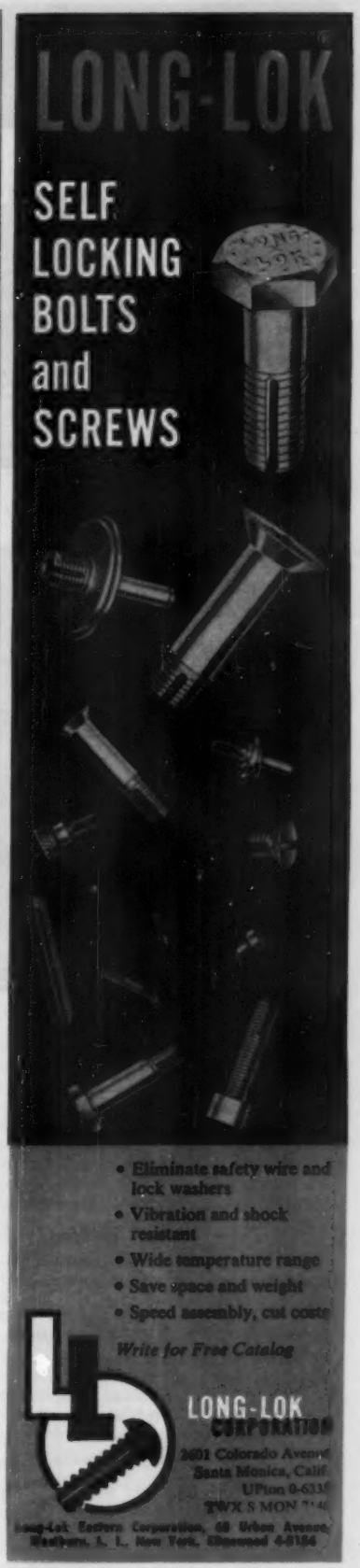
The Beech new dealer plan not only will considerably increase available airport sales and service facilities, but it should go a long way to alleviating serious problems in storage and service of the rapidly growing business fleet, and do this without government subsidy.

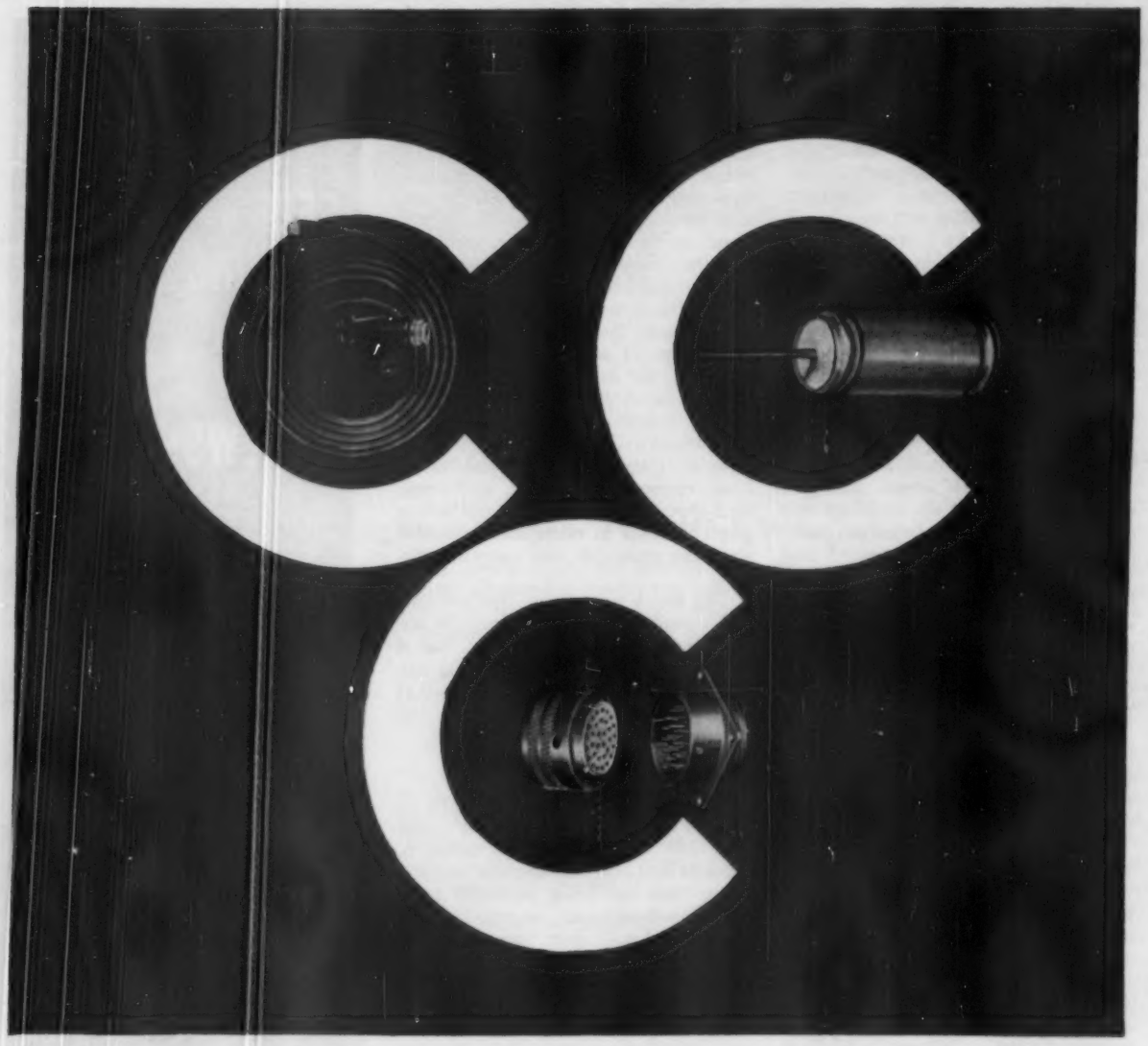
Expanded Market

Basically it will provide a greatly expanded market for the company's products—200 additional dealers would require at least 200 demonstrator airplanes more than are being produced today and their being active in new locations certainly should spur Beech sales beyond what is now being done.

It also will widen the avenue of increased spare parts and accessories business, an area the company is interested in expanding rapidly. It is for this reason that so much effort was expended at the recent distributor-dealer meeting on urging dealers to put greater effort on this business and they were told that they should increase customer exposure to parts and accessories, by "taking the mystery out of them" and bringing them out of the stockrooms and into a show-room area in the office space, display them attractively and promote them more. Increased attention to spares and accessories sales business last year resulted in an increase of sales in this area to around $5 million in the year past and the company is shooting for a target of $11.5 million in this segment of business in 1961.

Indications are that Beech is studying possibilities of having merchandise built for it with its brand name and merchandising this material as part of its over-all business. Build-up of its dealer representation would provide a greatly expanded promotion effort to increase this business.





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British Accident Investigation Report—Part II:

Slush Drag Led to Elizabethan Crash

Following is Part II of a report to the British Minister of Transport on a review of a BEA Elizabethan accident at Munich, Germany. Part I was published by Aviation Week *Nov. 28 (p. 103).*

We now turn to the deductions from the aforementioned facts, all of which were debated before us. It is an important preliminary to this matter to recall that a snowflake falling in a temperature below freezing point is "dry;" it is pure ice and contains no water; but that if it falls into an ambient temperature above freezing point its minute strands of crystalline ice begin to melt so that the snowflake then contains water and is "wet." Likewise if it falls on to an object itself above freezing point it commences to melt. If a dry snowflake falls on an object itself below zero it does not adhere to the object, but if a wet snowflake falls on such an object its free water refreezes and causes it to adhere to the object. The binding element in wing icing is freezing water. Now the air temperature at Munich airport fell steadily from the −0.2C recorded 4 min. before the last run to the −3.0C recorded at the time when the inspection commenced.

Unless, therefore, there was an abnormal variation between the temperature at the airport screen and that at the point where the wings came to rest, perhaps 1,500 yards distant, the snow falling at all times between the accident and the investigation must have been dry. Such snow falling on an aircraft wing coated with ice and ex hypothesi below zero would not adhere to the ice because there would be no free water present to bind the two together by freezing. The finding, therefore, of a layer of ice outboard of the engines covered with powdery snow which had not blended with the ice is consistent with that part of the wing being ice-covered at the time of the crash. Is it also consistent with its being free from ice at that time? If the wing were then clean, the ice can only have been formed by the melting of the snow that fell thereafter, and its refreezing as the temperature dropped.

There are two objections to this hypothesis. Firstly there is the question whether the wing temperature was at that time high enough to melt the falling snow, (which was only "slight snowfall" until 1850 hr.), bearing in mind not only the recorded temperatures but also the fact that the physical change from solid ice to liquid water or vice versa involves a heat transfer of 80 calories per gram (cu.cm.) of water. If snow is melted by falling on a wing of a temperature above zero, the act of melting itself thus extracts heat from the wing and lowers its temperature, so accelerating the cooling which was taking place during the time in question. The second objection is that, according to the evidence, the melting and refreezing process would not produce two disparate layers, one of clear ice and one above it of powdery snow, but would produce a blending between the upper ice and the lower snow, or as Dr. Penman put it, "some degree of adhesion" between the two. That witness said "as it is described to me now" (sc. marked lack of cohesion between ice layer and superimposed snow) "there is obviously a discontinuity in the physical system and one feels there must be discontinuity in the history of the formation."

As to the first objection, we were not invited to consider the point, dealt with in the German report, that the fires which broke out in parts of the wreckage raised the temperature either of the air or of the wing surface sufficiently to melt falling snow. Instead it was suggested to us, as it had been to the German Commission when the reopening of their inquiry was sought, that the use of fire extinguishing powder on the wing surfaces had the effect of lowering the freezing point of water. The powder, according to this submission, would lie more heavily in the area behind the engines and the difference in quantity, and in consequent effect on the freezing point, accounted for the difference in the conditions found behind the engines and elsewhere on the wings.

Supporting Contention

In support of this contention, Mrs. Thain gave evidence of experiments with a sample of the fire extinguishing powder used at Munich airport. The powder contained sodium bicarbonate and although it also contained a water repellent to prevent caking, she found that it went readily into solution in water, even when merely dusted on to a water surface, and that the freezing points of different concentrations of solution were as follows:

Solution:

1 in 1,000, freezing point	−0.4 deg.
1 in 100,	−3.0 deg.
1 in 10,	below −3.0 deg.

In addition, Mrs. Thain thought that the ice produced by the subsequent refreezing would be thicker than that produced by the freezing of rainwater. Her reason was that different constituents in the powder would crystallize out of solution at different points, providing, as the temperature dropped, a combination of solid and liquid matter which would be more viscous than the slush of water in the process of freezing and would stand on a slightly sloping wing to a greater depth than would water. However she had made no comparative tests of the viscosity of the solution while in process of freezing compared with that of water at the like stage. Of what may have happened, she said "I visualise that this snow could be intermittent or not heavy continuous snow, and that the snowflakes would fall, and where they came in contact with the powder they would melt. I do not think they would melt sufficiently quickly to enable the snow to run off, to enable the solution to run off the aircraft, and as the temperature fell you would reach a point (because you do not need a very high concentration to lower the freezing point) and somewhere between 0 deg. and −1 deg. the majority of the ice would form and the thickness would depend on how much snow you actually trapped in your solution. I do not think you can be specific on exactly how much snow would fall on how much fire extinguisher powder."

When it was suggested that her evidence did not account for the absence of ice beneath the dry snow behind the engines, she said "As I read the report, I visualised that Capt. Reichel brushed it away from the engine and found there was no ice, and I think one could mistake snow on top of a thick body of slush as complete snow, and that if one did that one would automatically dismiss the lot as snow, whereas in fact it could have been possibly slush in contact with the engine which he brushed off." In this connection Mr. Jones had suggested that the area behind the engines must have been hot at the time of the crash, so that snow alighting there would melt, that the finding of snow lying here at 2200 hr. showed that it had in the intervening time passed below freezing point, and that at the moment of freezing the melted snow lying on it must have turned to ice. He could not understand why there was not at least a film of ice behind the engines under the snow.

Capt. Thain said that the fire extinguishing powder was projected from a portable apparatus. The apparatus delivered a powerful jet of powder and he saw it used to extinguish a fire under the starboard wing. The fireman started to move away to a house which was burning, but Capt. Thain called him back as the fire under the starboard wing had reignited: "I stood there while the fireman put out the fire for the second time . . . there is no doubt that he gave the starboard engine a jolly good dousing." He saw him hold the nozzle six to 10 ft. from the starboard engine, round which he concentrated. He did not see the fireman applying powder to any other part of the starboard side, nor sprinkling the starboard wing as a precautionary measure.

We accept Mrs. Thain's evidence as to the lowering of the freezing point of a solution containing the powder, and if there had been any evidence of a distribution of powder over the whole of both wings, this factor would explain some melting and refreezing despite the prevailing temperature. But in our view it does not explain the discontinuity between the rough ice and the superimposed snow, nor does it explain the absence of ice behind the engines. The last-named finding is a puzzling feature on any view of the matter. If any substantial part of the wing was heated by the engines, either this must have cooled very rapidly at a time when no snow was falling, or there was inaccurate or insufficient observation. It is here that we encounter a difficulty inherent in the nature of our inquiry. Our

function is to consider Capt. Thain's representations and the German report. As already mentioned, Capt. Thain's representatives furnished us with a great deal of the material which was before the German Commission, but they were not of course in a position to call Capt. Reichel or his assistants, whose evidence is the foundation of this part of the case. This evidence was accepted by the German Commission, of which Capt. Reichel was a member, and it would be improper for us to speculate as to whether, for example, the number of spot checks taken was sufficient or whether the investigators had mistaken dense slush for dry snow.

We feel at liberty to criticise the reasoning of deductions set out in the German report, where such criticism is relevant, but it is out of the question to criticise evidence of witnesses we have not seen or to speculate on what answers they would have given to questions on details of their observations. These considerations lead us to say that we have insufficient information to enable us to decide whether or not, by reason of the prevailing temperatures, the ice found at 2200 hr. could not have formed after the accident.

It was further submitted to us that 5 mm. must in any event be an overestimate since the snow equivalent of a maximum depth of only 2 mm. of water had fallen during the aircraft's stay at Munich and if the whole of this froze on the wing it could produce an ice layer only fractionally deeper than 2 mm. Furthermore some of the precipitation had been seen running off the wing by witnesses. This is in our view a convincing point: we discuss below how far pre-takeoff conditions can have permitted ice formation, and we think it true to say that if the post-accident ice was 5 mm. thick it could not have been formed from pre-accident precipitation, and that if it was formed from pre-accident precipitation it would not have been 5 mm. thick.

Spray Effect

It emerged during the evidence that during its last run the Elizabethan threw up clouds of spray. Mr. Black said "the aircraft went along the runway as if it were a snowplough" and later said "It just looked as though a flying-boat was taking off." He added that the unusually low fuselage of this type of aircraft seemed to be deflecting the spray. If this happened during the last run it would appear that it must have happened on the first two runs. Now, as we shall see, what was lying on the runway was melting snow, slush, or water, and if any of this spray landed on the wings and if those wings were at the appropriate temperature the wet spray would freeze and adhere. This point does not seem to have emerged until our inquiry, and there are no experimental or other data to show the trajectory of spray thrown up by the wheels at the relevant speeds, but it seems not impossible that it should reach the wings, except perhaps in the propeller slipstream since the blades might intercept and scatter it. In considering the origin of the ice found at 2200 hr. therefore, there is a possible source other than natural precipitation which in our view merits investigation. It was not investigated before us because Capt. Thain through his counsel did not wish to make a point of it.

Having assembled the facts and supporting evidence, we have to see whether they lead, as was submitted, to the conclusion that at the time of the last attempted takeoff the wings were free of ice. We see no reason to doubt the eye-witnesses who saw melted snow running off the wings at or shortly after the time of refuelling. This points to the wings at that time being appreciably above zero centigrade. The last person to note this was Capt. Thain and no one speaks of this happening after he had embarked, a fact consistent with our view that the wings were then at about zero. The time of Capt. Thain's observation is not known but assuming it to be 1500 hr., there elapsed an hour between it and the final run, during which 20 min. was spent in taxiing, holding, making two abortive runs, and returning. During that hour the wings could have been at any temperatures between say +0.5C and −0.5C according to what local variation from screen temperature existed. It is impossible to assert that they must have been thawing or must have been freezing at this time. In one of the documents before us, Mr. Jones, starting with the assumption that the wing had cooled from +10C on arrival to zero in 30 min. or less, proceeded as follows: "If the ambient temperature is 0C and the relative humidity very high (i.e. wet bulb temperature also very close to 0C) the wing when cooled to 0C in about half an hour will remain at 0C and there will be no further melting of snow as it falls and the freezing process, if any, will be very slow indeed. The wing will remain wet with a maximum of ½ mm. of water depth on it (from the half hour's melting although, of course, some water must have run off) and the subsequent snow will accumulate on the wing, i.e. snow equivalent to about 1 mm. of water, corresponding to the snow falling between 1447 (half an hour after landing) and 1550. At 1550 the snowfall became very light and at 1600 the temperature in the meteorological enclosure was −0.2C and the relative humidity had fallen to 91%. Slow freezing was then inevitable provided the air temperature in the meteorological screen was typical of the air over the whole aerodrome.

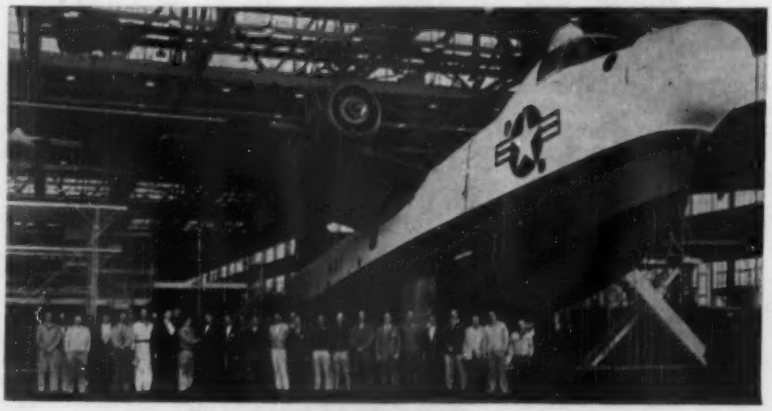
"When dealing with temperatures to one tenth of a degree, no meteorologist could state positively that this was so. The small margin of temperature therefore makes it impossible to say with certainty that freezing was proceeding. All that seems reasonably certain is that there was snow on the wings and that beneath the snow there was a thin layer of water or ice. Freezing of the water film . . . would cause some of the snow above to be held and would lead to a rough surface to the ice. It could be argued, and no one I think could positively contradict it, that the freezing of the wet film containing embedded snow occurred after the accident since the temperature continued to fall after the accident."

That analysis demonstrates both the theoretical uncertainties of the situation and how crucial the prevailing meteorological conditions were to the aircraft's safety. Do the observations of the eye-witnesses during the second visit to the apron help to resolve the uncertainties? We accept, without attaching great importance to, Capt. Thain's observation of the small portion of wing he could see from the cockpit. We think the witnesses who looked down from the terminal building, corroborated by the photograph, establish that snow was lying on the wing and not melting; whether there was ice under the snow they could not tell. It was submitted that the above-mentioned photograph showed some water lying under the starboard wing at 1550 hr. and that this water must have dropped from the wing.

Darkness on Ground

We agree that the darkness on the ground, contrasting with the white track-marked snow elsewhere on the ground, is probably water; it lies beneath the inboard section of the wing, largely in the vicinity of the engine, where melting of any falling snow would certainly take place. Whether this water came from this aircraft or from another aircraft which, as the tracks show, had previously stood there, and whether it fell from the trailing edge of the wing or from the vicinity of the engine and ran into the position seen in the photograph, it is quite impossible to determine. We do not think the photograph helps us in this respect.

Whether or not there was ice under the snow on the wing, and whether or not, if so, the snow was freezing to it and thickening the layer, depends upon a temperature variation within so small a compass that, in



Final Martin P5M Marlin

Final Martin P5M-2 Marlin ASW amphibian is seen at Martin's Baltimore plant after coming off the assembly line. P5M-2 is powered by two 3,400-hp. Wright R-3350-32W Turbo-Compound engines. Aircraft first flew in August, 1953.

the light of the evidence of Dr. Penman and Mr. Jones, we are unable to find that the presence of ice is conclusively established, although on balance of probability we think it not unlikely that there was at least a thin film of ice present under the snow.

The German report is in substantial accord with our reasoning as regards the position up to 1500 hr. It says, "It is true that in the case of the first takeoff at 1519 hr., at a temperature of approximately 0C, the humidity of the air still amounted to 96%. Cooling by evaporation will thus still have been slight at this juncture. Only a film of ice will have formed on the cooled wing, under the layer of snow observed." However it goes on to say, "When the last takeoff was initiated, however, the air temperature was already —0.2C and the humidity of the air was 91%." Thus there existed conditions which point to the fact that by the time the aircraft taxied out for the third takeoff and during the first phase of takeoff, the cooling by evaporation had become so highly effective that the wet snowy mixture turned into the rough sheet of ice which was observed in the late evening of the same day.

We were pressed to say that the reasoning in the latter passage was erroneous, and Dr. Penman was called expressly to deal with cooling by evaporation. We need not however comment upon his calculations since we differ from the view of the German Commission as to what happened after 1500 hr. because we cannot accept the proposition, underlying their reasoning, that the air temperature at the wing was exactly the same as that at the screen. Moreover we think that factors other than evaporative cooling, such as the temperature of the uplifted petrol, could be at least as powerful in influencing the temperature of the wing.

Critical Conditions

It is well known to pilots that ice may form in critical meteorological conditions such as those outlined above, and it is common practice for precautions to be taken in such conditions. See for example Civil Aviation Information Circular No. 150 of 1954, "The Effect of Frost, Ice and Snow on Aircraft Performance, Precautions before Takeoff," para. 4(b)(iv) of which states that snow "will also be liable to freeze to the surface if the temperature has fallen from just above freezing point during the snow. It is never safe to assume that snow, though apparently of the dry variety, will be blown off during takeoff. . . . Particular care is necessary when the temperature is in the neighborhood of freezing point and delay occurs between the removal of the snow and takeoff." An example of the steps taken in the prevailing conditions is afforded by the evidence of Capt. Wright. On arrival he inspected the wings of his Viscount. Asked whether this was a routine check he agreed but added "in those circumstances of temperature I would say a specific and special check." He climbed on a stand in order to inspect his wings: he found a little water and melted snow and if he had departed then he would not have de-iced the wings. (He had had his de-icing equipment switched on while descending through cloud but thought it had been switched off before landing.) When about an hour later he was ready to embark his passengers he inspected again; heavier snow was falling and he found it freezing to the wings. He therefore had the aircraft de-iced.

The Viscount took off at 1720 hr. Asked why he regarded his first check as special, he said "because of the temperature and the fact of the temperature dropping slowly with the length of time on the ground, getting dark, and temperatures obviously falling, and as a matter of interest with a slight precipitation forming of any frozen kind I would always do that." He had ascertained the temperature from the Meteorological Office. His evidence continued:

"Q. Would you regard the temperature being at or about zero as being important in your consideration of de-icing?

A. Yes, obviously so. In relation to my first check on the wings, the amount of precipitation, melted snow, water, was the first consideration. If there had been more present at that temperature then I would have had it de-iced, but there was so little . . . it was so very little as to be negligible."

The German Commission had evidence that similar precautionary action was taken by those responsible for the other aircraft taking off from Munich that afternoon. The report went on to say: "In the case of all the other aircraft which took off that afternoon snow had, in fact, collected on the wings and in each case it had been removed by personnel of the air transport undertakings." This refers to four aircraft other than the Elizabethan and the Viscount, namely a DC-3 departing at 1408 hr., a DC-7C at 1433 hr., a Convair at 1544 hr. and a DC-6B at 1554 hr. (The German report appears to be inaccurate in stating that 16 aircraft landed and took off in the course of the afternoon. We were supplied with a memorandum from the station superintendent, Munich, showing that after 1300 hr. (midday GMT) eight aircraft landed and the six mentioned above departed.)

Capt. Thain described his action in detail when giving evidence to us. On alighting at the apron he found the ground covered with watery slush and pools of water about an inch deep. Fifteen or 20 min. later, after completing the flight plan, he met Capt. Rayment and discussed the snowfall on the wings: "He told me that he had looked at the wings and in his opinion they did not need sweeping." He agreed with him. Asked why he agreed, he said "I could not think of a better authority than Capt. Rayment, a senior captain in BEA. He had gone out and looked at the wing and he came back and told me he had done so." This conversation took place outside the Air Traffic Control Office, in view of the aircraft. Capt. Rayment did not say how he had looked at the wings, nor did Capt. Thain ask him, but Mr. Black was then on top of the wing and there would be a ladder in position for his use. Capt. Thain said, "I think there is every likelihood that Capt. Rayment would have used that ladder."

Running Water

After the conversation, Capt. Thain visited the BEA office, signed the ship's papers, and returned to the aircraft, at this stage making the observations of water running from the wing already detailed above. Before he embarked he was approached by the station engineer, Mr. Black, who asked him if he required the aircraft to be de-iced. Capt. Thain did not remember this conversation but accepted Mr. Black's

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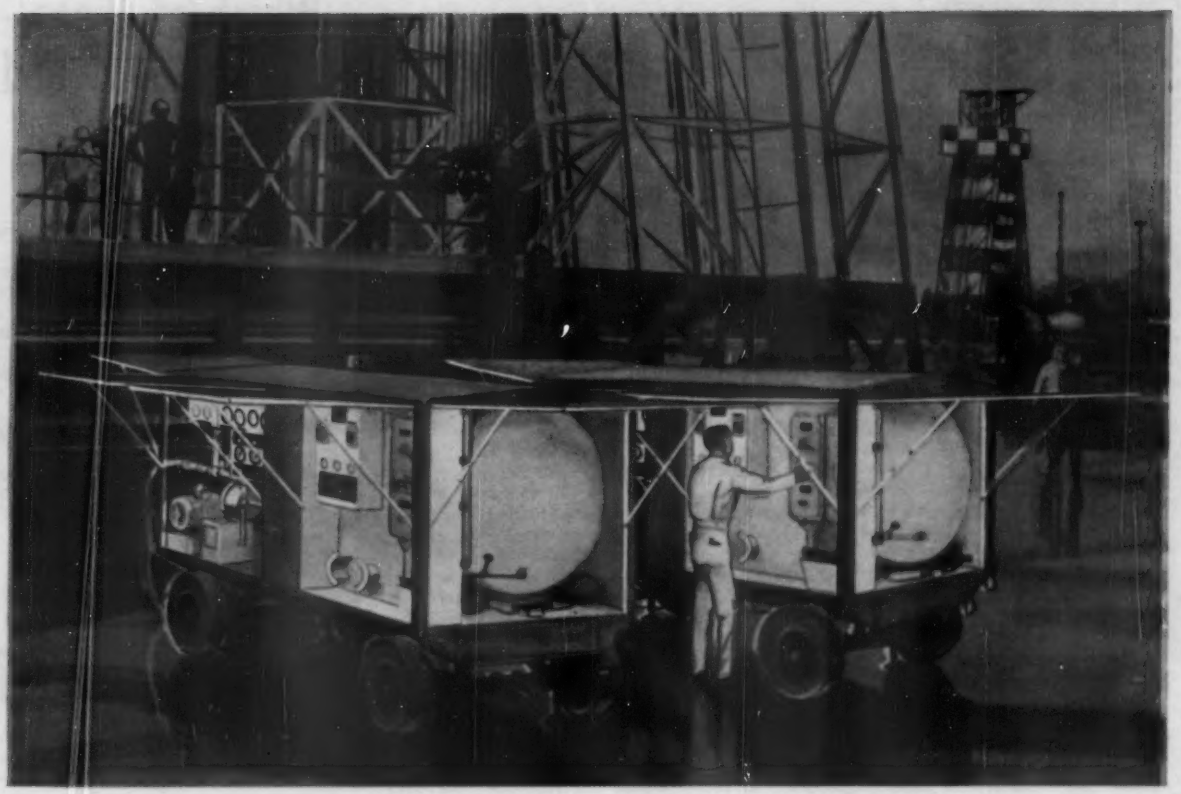

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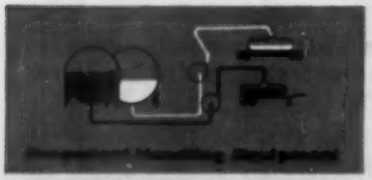

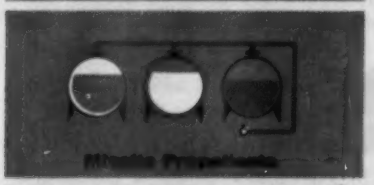

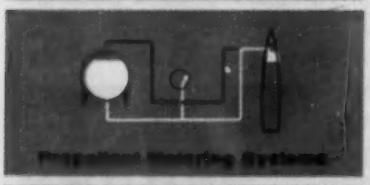

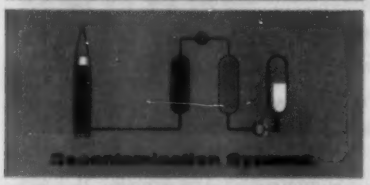

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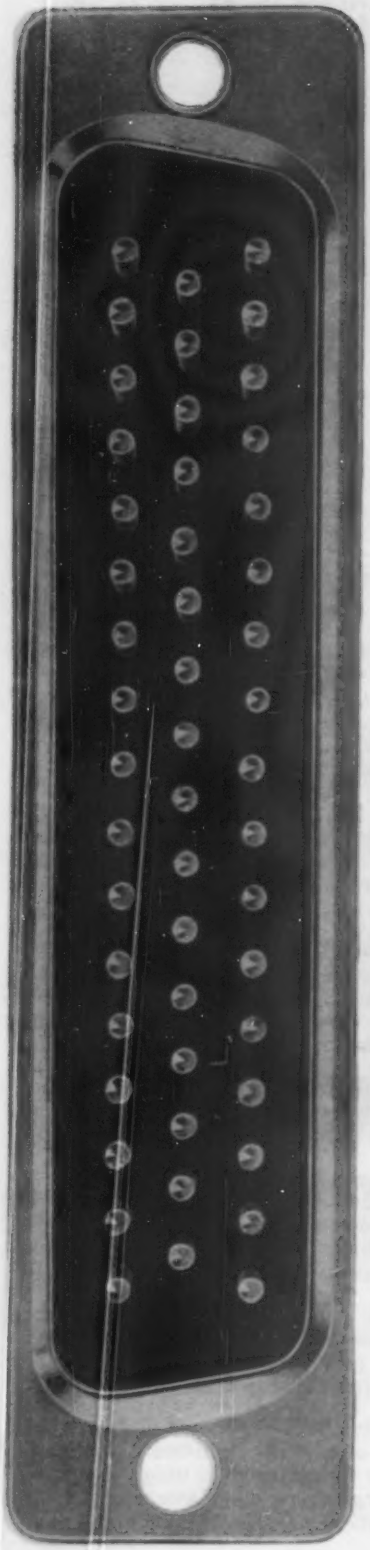

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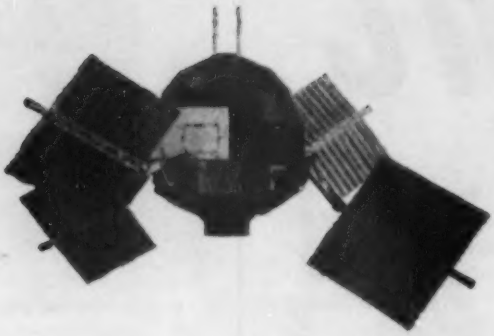

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evidence which was that in reply to the question Capt. Thain said that he did not consider that the aircraft required de-icing at all. After embarking for the first attempted takeoff, Capt. Thain made no further observation of the wings from the cockpit. He said he had by then satisfied himself of the position.

The following are his answers in this respect to his counsel:

Q. Did you consider at that stage, just before the first takeoff, that there was any need whatever to sweep snow off the wings?

A. It is always a possibility when you have got snow falling.

Q. But did you consider it necessary to do so?

A. No, there was insufficient; you have got to have snow to sweep off.

Q. And you had addressed your mind to it?

A. Absolutely, and I decided that, with the very very small quantity that was there, it was not necessary to sweep it off.

Q. And it was actually snowing at the time, was it?

A. Very lightly.

Later, before the final attempted takeoff, Capt. Thain again considered the question of snow on the wings. His observations from the cockpit window have been given above. He said he discussed the matter with Capt. Rayment, who reported seeing the same conditions on the port wing, and formed the view that there was no necessity for the wings to be either swept or de-iced. By this time, he said, there was virtually no snow falling, only "a flake here or there."

Capt. Thain was asked by us whether he had ascertained the ground (screen) temperature. He could not recall having been told this before landing, nor making inquiries about it when visiting the meteorological office.

His evidence continued:

Q. Did you think it important to make any inquiries about the temperature?

A. I think I was aware of the fact that the temperature was approximately zero.

Q. But in connection with any ice on your aircraft, that was the most critical temperature in the whole thermometer, was it not?

A. Yes, but at the same time I was aware of the fact that the temperature when I arrived at Munich was certainly not below zero, but was above it.

Q. What made you think that?

A. Perhaps by experience. . . . There was snow falling at the time when we arrived there, and the snow which was falling was wet snow.

Q. You are saying it was wet snow, and therefore you thought the thermometer was above zero?

A. Yes. . . .

Q. Did you change that view at any time up to the accident?

A. No. . . .

Q. Did you give any thought to the possibility that it might be going below zero?

A. I did not think it would be going below zero.

Q. Why not?

A. At that particular time it was not far advanced in the afternoon. There was complete cloud cover. . . . I did not expect the temperature to fall below zero, or to zero."

Capt. Thain said he was well aware of the dangers of icing. He was familiar with Circular 150 of 1954 and with a BEA instruction that "captains should . . . make absolutely certain immediately before takeoff that the lift and control surfaces of their aircraft are clear of snow." He said that if he had thought that his wings had a temperature below freezing he would have had them de-iced. He agreed that on his second visit to the apron he took no steps to satisfy himself about wing conditions except to observe from the cockpit window, and that inside the cockpit he was not in a position to check the outside temperature (except by radio, which was not used). As to his decision before the last run, he was asked:

Q. Is it fair to say you were going on general impression and general feeling rather than on any observation or any concrete information about temperature?

A. My opinion was based on what I had seen of the snow melting on the wing, and the general feeling that I had.

Q. Yes, of course that was some considerable time earlier, was it not?

A. It was earlier." . . . (He said it was about 40 min. earlier).

Q. You did not think it right, in view of that lapse of time, to ask for specific information about temperatures, or have a look at your wings a bit closer too?

A. No, I was satisfied when I saw that the snow that had been on that wing had been blown away, the aircraft did not have any snow on it."

Shown the photograph referred to above, Capt. Thain agreed that it gave the impression of a wing covered with snow outboard of the propeller slipstream but free of snow behind propeller and engine. He agreed that the alteration in color at the edge of the slipstream could not be accounted for by the band of anti-corrosive paint. Asked what could account for the change of color, other than the edge of a covering of snow, he could offer no explanation.

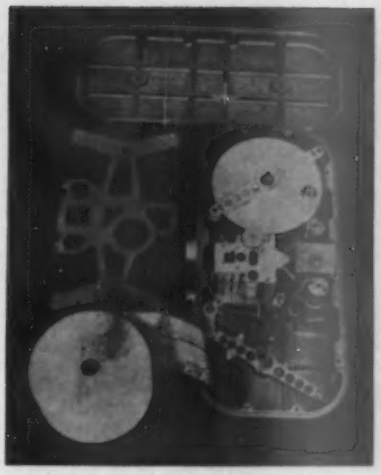
Upon the evidence it was submitted on Capt. Thain's behalf that he had acted correctly; that every indication which he had pointed to a thaw; and that a captain could not be expected to have moment-to-moment reports of temperature changes. It was further urged upon us that the amount of ice which could have formed between the first and last departures was infinitesmal, and that we must consider the position of a captain with a great deal on his mind. Our opinion on this part of the matter is given below.

The runway at Munich has been lengthened since the accident. It was then 1908 m. long (2,087 yards). It is 200 ft. wide and lies at a compass bearing of 249 deg. At the material time aircraft were landing and taking off from E-N-E to W-S-W. At its nearest point (about two-thirds of its length, starting from the east) it was approximately 930 m. from the terminal building. The surface was concrete, slightly cambered.

The only witness, so far as we are aware, who examined the runway from the ground at the time in question was Herr Bartz, whose evidence to the German inquiry is quited in extenso above. Direct evidence at our inquiry was given by three pilots, Capt. Wright, Capt. Merrifield and Capt. Thain.

Capt. Wright landed his BEA Viscount 5 min. before the Elizabethan's last run. In fact the latter was holding at the end of the runway when the Viscount landed. Capt. Wright, looking down from an eye-level height about 10 ft. from the ground, observed the ruts made by aircraft wheels in the snow or slush covering the first two-thirds of the runway and from them estimated that the depth of cover was one to one and a half inches. The last third was covered in slush with large pools of water. He saw distinct banks at the edge of the runway, as though the snow had been swept earlier. The snow or slush on which he landed had a retarding effect, so that instead of having to brake, as he would have had to do on bare concrete in calm conditions, he had slowed to taxiing speed by about the midpoint in the runway and thereafter applied power. While taxiing he was asked by control to report on braking action; he applied his brakes and found that "a fair amount of braking could be applied without causing any sliding." When taking off again for London at 1720 hr. the Viscount again experienced retardation attributable to the slush: it was the practice to time the run with a stopwatch; in ordinary conditions, with the aircraft lightly loaded as this was, the elapsed time to V_2 of 106 or 107 kt. would be about 23 sec., but to the best of Capt. Wright's recollection it was on this occasion nearer 30 sec. and the aircraft used about two-thirds of the runway before unsticking.

On arrival at London Airport it was found that the nose-wheel of the Viscount had on the takeoff accumulated a great deal of slush which had turned to ice: the back of the oleo and the steering jacks were covered with a thick coating of ice, estimated as



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varying between 2 and 5 in. in thickness: the steering jacks had disappeared in a ball of ice.

Capt. Merrifield had landed another BEA Viscount at Munich two days later, on Feb. 8, 1958. By then a thaw had set in and from the air the runway appeared clear although the grass areas of the airfield were still snow-covered. About half way down the runway this witness found a large pool of water 200 to 300 yards long on the northern side of the concrete and extending to the half-way mark. He landed on the south side to avoid the pool.

First Touchdown

That part of Capt. Thain's evidence which dealt with the runway was as follows. "When we first touched down the aircraft was inclined to slide on what I thought to be some packed snow, it was slippery. When we got further down the runway we found that the precipitation or snow on the runway was rather different: it was watery, there were some bare patches and the braking effect was quite satisfactory. I reported this to the control tower." He did not recollect whether a special braking test was carried out, as in Capt. Wright's case, but thought they would have braked in the normal way: it was Capt. Rayment who operated the brakes. He did not remember his aircraft being retarded by slush as the Viscount had been. He recalled nothing special about the state of the runway. On the first abortive takeoff the aircraft stopped and turned approximately 400 m. from the end of the runway, and on the second it taxied to the end in order to return to the terminal by the perimeter path. He did not see the banks of snow on either side of the runway spoken of by Capt. Wright, nor anything unusual in the state of the runway. When taxiing back after the second run he had difficulty in identifying the edge of the perimeter path owing to the snow: there were no tracks of other aircraft to be seen on this path, so far as he remembered.

We may summarize the direct evidence by saying that while Herr Bartz, who examined the runway at about 1535 hr. both from a vehicle and on foot, gives a picture of a runway covered with slush of a uniform depth and consistency ("a jellified water mass . . . approximately ½ to ¾ cm. deep"), the two pilots noted a difference in condition between the easterly two-thirds and the westerly one-third, and one of them gave an estimate of the depth of the first part as five times greater than did Herr Bartz (one inch = 2.540 cm.) None of these witnesses observed any significant change in the depth of the cover nor did the pilots experience any increased drag at any particular part of the runway. With these considerations in mind we proceed to see what light can be thrown on the matter by the behaviour of the aircraft on its third and final run.

The part of Capt. Thain's written statement dealing with this run has been reproduced above. In evidence he was asked what happened when the needle of the ASI reached 117 kt. and answered "The needle hovered at that speed; it was flickering. I waited for an increase in speed, but it did not come forward, and after a few seconds at that speed the indication fell off about four or five knots. It was flickering quite a lot. It paused at about 112 kt. and then it fell off again to 105, flickering quite a lot. I thought I felt at that time —well, I certainly felt a lack of acceleration, but the thought passed through my mind about the accuracy of the instrument. I could not make up my mind. The next thing that happened was a cry of alarm from Capt. Rayment." He had no idea how much runway they had used when V_1 was attained; he said the needle stayed at 117 kt. for "several seconds" and at 112 kt. for one or two seconds.

While the speed was at 117 kt. Capt. Rayment was operating the elevator trimmer. He did not look up from the instruments until Capt. Rayment's ejaculation: "When he uttered his cry of alarm, things happened very quickly indeed. I looked up, banged the throttles, and almost at the same time he called 'undercarriage up.'" He was "pretty sure" they had not then reached the end of the concrete. It was afterward ascertained that the nosewheel retracted but the main wheels did not. He was not conscious of the nosewheel retracting, but "I was aware of a strange feeling of believing that I was airborne. We had at that time reached a very smooth passage." At this stage the nose of the aircraft was up, but he had no knowledge of the aircraft's attitude up to the time of his colleague's cry. He himself did not close the throttles.

Controller Observations

Further evidence of this attempted takeoff is provided by the observations of the two air traffic controllers, Laas and Gentzsch, summarized above and by the tracks of the aircraft's wheels. The evidence of the tracks was given in the German report as follows:

"From the point at which the aircraft had broken through the fence its tracks could clearly be discerned, extending back to the runway. The double track of the right side of the undercarriage could be followed back to the runway without difficulty. The left-hand wheel track was interrupted in places. Nowhere was there any nosewheel track to be seen.

"From the end of the runway to the fence, in the direction of takeoff, the wheel tracks showed a slight swing to the right. Two days after the accident, when the snow had melted, the tracks were particularly clearly visible. On the runway, about 50 m. short of the end, a skidmark began. It was clearly visible on the concrete and from the strewn sand which the wheels had pushed aside. . . . This mark showed that at this point all four wheels of the main undercarriage were locked. This skidmark continued for approximately a further 30 m. beyond the end of the runway. It then stopped and there remained the impression of the free-running wheels on the grass surface. The track of the right-hand twin wheels was strongly marked; that of the left-hand wheels was fainter and at times interrupted. The track of the right-hand wheels was uniformly clear throughout the whole length (250 m.) of the stopway as far as the point at which the aircraft crashed through the fence. The left-hand wheels had at times left the ground. The skidmark and wheel-marks were still clearly visible at the time of the survey of the scene of the accident by the Commission of Inquiry on 30th April, 1958."

The track of the rear wheel was also vis-

ible in the snow at the end of the runway: see the statement of the witness Meyer, mentioned above.

The time taken by the run can be gaged with accuracy from the transcript of the tape recording of R/T communication between the aircraft and control, in conjunction with the written statement of Mr. G. W. Rodgers, the radio operator of the Elizabethan. He reported "rolling" as the aircraft began to move, this being recorded at 1603.06 hr. He heard Capt. Rayment call "undercarriage up" and immediately called control but "before I could do more than give the call sign the aircraft crashed." The tape records this message as commencing at 1604.00 hr.

Relevant data is also furnished by the Peravia recording of the port engine performance referred to above. On the recording the time scale is 2 min. to about ½ in., so that precision as to seconds cannot be obtained, but Mr. Kenward, who interpreted it in evidence, thought he could certainly read it accurately to within 5 sec. Two traces were recorded on the wax cylinder, one showing boost pressure, the other rpm. The boost pressure trace shows that from the opening of the throttle power was applied for approximately 50 sec. After 20 to 25 sec. the recording fell from about 59 in. to about 54, presumably from throttling back, but after 10 to 15 sec. it returned to 59, staying at this pressure for a further 15 sec. approximately after which it fell abruptly below static pressure, indicating that the engine was throttled right back, remaining there until it reverted to static pressure, as it would when the engine stopped. The importance of the record lies in its corroborating Capt. Thain's evidence about throttling back during the run, and in its demonstrating that the throttles were cut an appreciable time before the crash. Owing to the coarseness of the scale it is impossible to be precise about the length of this time or to say at what point on or after the runway it occurred, but Mr. Kenward thought it clearly corresponded to a point either near the end of the runway or on the overrun area. This, it will be recalled, is the vicinity where the skidmarks appeared, and as Capt. Thain neither closed the throttles nor braked, it is not unlikely that the beginning of the skidmark represents the point where Capt. Rayment cut power as well as braked.

Airspeed Drop

The outstanding feature of Capt. Thain's evidence is his firm recollection of the airspeed dropping from 117 to 112 and then to 105 kt. The German Commission rightly pointed out that "for subjective reasons, statements by witnesses are subject to error precisely when it is a question of giving an account of what happened in an unnerving catastrophe." Memory plays strange tricks with the victims of shock. We do not doubt, nor did the German Commission, that Capt. Thain was giving his honest recollection, but in the circumstances it may not be an accurate recollection. It is certainly a consistent recollection: Capt. Thain mentioned the drop in speed when interrogated by Capt. Reichel two days after the accident, according to the transcript of the interview furnished to us.

It was submitted on Capt. Thain's behalf that, accepting his evidence as accurate, the remarkable deceleration of which he

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spoke could only be attributed to an increase in either the depth or the density of the slush or both. The German report reconciled the evidence with their view of what happened by attributing the drop in speed to the applying of the brakes by Capt. Rayment and by stating that the sequence of Capt. Thain's account showed that the deceleration took place towards the end of the runway. We find it difficult to follow this reasoning. Capt. Thain's statement appended to the German report does not, as it seems to us, necessarily indicate that there was little lapse of time between the deceleration and the witness looking up and seeing the house in front of him. Moreover, Capt. Rayment's cry "Christ, we won't make it" can only indicate that up to then he had been trying to make it, and if that is so he cannot have applied the brakes until at any rate the moment of the cry. Yet this was after the deceleration first to 112 kt. and secondly to 105 kt., according to the statement.

If Capt. Thain's recollection has transposed the order of events, it is unreliable and must be rejected. On the other hand it is honestly and consistently given and is entitled to consideration. If it is correct, we cannot accept braking as the cause of deceleration and must look elsewhere. Moreover, even if Capt. Thain's recollection has transposed the order of events we do not think braking can have caused the deceleration of which he spoke. The wheels were locked for 90 yards, which at 117 kt. would be covered in 1½ sec. A deceleration of 12 kt. in this time is nearly ½g; this would be impossible in the conditions obtaining even if the wings were not lifting at all. Since the aircraft was at full incidence, such a deceleration is doubly impossible as a result of braking alone; the probable loss in the conditions obtaining would be 1 to 2 kt. at the most.

The deceleration must be caused by either a diminution of power or an increase of drag. There has never been any question of the former and the cause of the deceleration must have been drag increase. We have considered possible causes and can find none save an increase in the depth or density of the slush. According to Capt. Wright as well as Capt. Thain, the slush changed in character two-thirds of the way down the runway from being predominantly snow to being predominantly water, i.e. its density increased. This, if the depth remains constant, must increase its drag, and if the increased drag is applied to the main wheels, the nose wheel then being clear of the ground, the resulting pitching moment may return the nose wheel to the ground. Once that happens, drag increases further since it is applied to six wheels instead of four. It is in this connection that the evidence of Laas, mentioned above, assumes significance. Laas's statement says "The aircraft gradually built up speed, the nose wheel leaving the ground approximately half-way along the runway, but the aircraft did not become airborne within a period which could be considered as normal. I then observed that the pilot pressed the nose of the aircraft down again, until the nose wheel touched the ground, as if he wanted to gain extra "play" in order to pull the aircraft off the runway, but I could not make out with the naked eye whether the aircraft actually became airborne." This clearly accords with the possibility outlined

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above. It is also consistent with Capt. Thain's evidence that when the acceleration was checked at 117 kt. Capt. Rayment was operating the elevator trimmer. The question arises whether it is also consistent with scientific knowledge of the drag effects of slush of varying density.

At the time of the accident very little was known about slush drag, and Dr. Schlichting was driven to employ the assumption that this drag could be expressed as an increase in the coefficient of rolling friction, taking arbitrarily double or alternatively treble this coefficient for his calculations. Since that time, however, and partly because of this accident, more has become known on this subject, and it is now believed that slush drag increases with speed (as indeed Dr. Schlichting suggested) whereas rolling friction decreases with speed as the weight is taken on the wings. One of our number, Prof. Collar, has prepared a paper giving tentative conclusions based on data now available.

We attach this Appendix in order to show that there is nothing improbable in Capt. Thain's account, particularly of the deceleration. If it is correct, it leads to the conclusion that, just as Capt. Rayment was about to lift his aircraft off the runway his nose-wheel came down and by the time he had lifted it off by elevator trim he had lost the minimum speed (110 kt.) at which, with a clean wing, he could fly off. This interpretation explains the accident without postulating wing icing, although of course it does not disprove icing, and it is because we think this is a feasible explanation of the events that we have already stated that no firm conclusion as to ice can be drawn from the performance of the aircraft.

Lack of Evidence

But we are far from saying that this is what must have occurred. We are not required to ascertain the causes of the accident, and if we were so required we should be unable to do so for lack of sufficient evidence. The reconstruction conflicts with the evidence of a number of persons whom we have not seen, for example Gentzsch, whose statement about the run is "It began rolling normally and built up speed until it was about half-way along the runway: the nose wheel left the ground, but touched down again after about 60-100 m. The aircraft continued to roll as far as the very end of the runway. . . ." Also Schombel, whose evidence on wing icing is referred to above, watched the run, and gave this account: "During the takeoff it struck me that, approximately from half-way along the runway, the pilot was trying, with all his might, to get the aircraft off the ground, and I noticed the particularly large angle of attack. The nose wheel was high in the air, the emergency tail wheel, according to my observation, was on the ground. This attitude became slightly modified during the takeoff process. The nose wheel remained off the ground." Bartz's evidence likewise, as to the uniformity of the slush, cannot be reconciled with this reconstruction. We have already indicated above that it would be wrong to criticize persons who have not given oral evidence before us; it would be equally indefensible to pick out statements favorable to a theory and reject others.

The German Commission saw the witnesses, or such of them as they wished to

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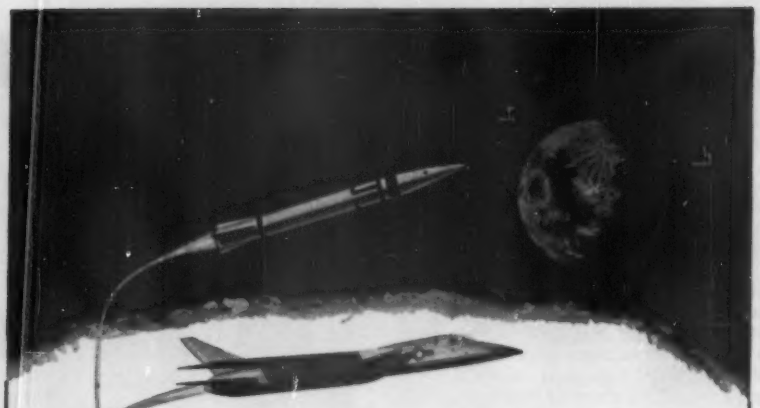

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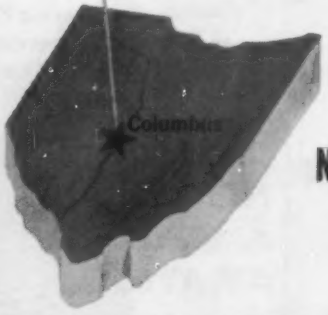

COLUMBUS DIVISION
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see, and rejected the view canvassed above. We have neither the material nor the wish to say they were wrong. What we can say, however, is that their conclusion is not reconcilable with Capt. Thain's evidence. We have already given our views on the suggestion that the deceleration was caused by braking: a further point is that the German Commission's reconstruction of the run takes the aircraft to 117 kt. at between 1400 and 1600 m., whereas the deceleration by braking, as shown by the skidmark commenced at 1850 m. If the aircraft reached 117 kt. by 1600 m. it should have reached a higher speed by 1850 m. unless indeed the slush drag was such as to render 117 kt. the maximum obtainable speed. Prof. Schlichting shows the aircraft reaching 117 kt. at 1550 m., 120 kt. at 1650 m., and 123 kt. at 1800 m.

We may leave this part of the case by saying that the only evidence of deceleration during the run (apart from the braking at the end of the runway) is that of Capt. Thain. We have no reason to reject it, and it is not inconsistent with much of the other evidence, including the time factor. It is however inconsistent with some of the evidence, as mentioned above, and if it is unreliable, its unreliability is accounted for, without the slightest criticism of Capt. Thain, by the effect of shock. If one discards this evidence, the aircraft attained V_2 but failed to unstick owing to icing, or the slush was of sufficient depth to prevent V_2 being attained (Prof. Collar calculates that on the basis of the data given an Elizabethan with a clean wing would require the whole runway to attain V_2 if there were uniform watery slush of a depth of 0.8 in. whereas with the slush depth given by Bartz of ¾ cm. and a clean wing it would achieve V_2 at 1300 yards); or of course there may be a combination of the two factors. Therefore having considered fully Capt. Thain's representations concerning the final run we are unable to make any useful deduction as to either the presence of ice or the degree of slush drag.

Similar Conditions

Capt. Thain's description of the runway conditions has been recorded above. He did not regard it as in any way unusual or unfit for use. However, he had had no great experience of such conditions in the past; asked whether he had encountered similar conditions before, he said "I suppose I have at one time or another . . . My particular experience was probably less than average because I have been, since joining BEA, on flights operated down to the Mediterranean." Before the outward journey to Belgrade he had not been to Munich for "five years, may be three." Prior to the final run, the Elizabethan had twice that afternoon taxied over the western end of the runway, once on landing and once after the second run, and after the first run it had passed the halfway mark. We asked Capt. Thain some questions regarding his observations on these occasions:

Q. Did it occur to you on any of those three occasions when you were at the western end of the runway that in the conditions it was a matter of some importance to know what the runway was like throughout the whole of its length?

A. Yes.

Q. Did that lead you to take any special precautions by way of looking or gaging what the position was?

A. Well, I was not concerned at all by the deposit of slush on the runway.

Q. Why not?

A. It did not present a problem.

Q. Would you like to expand that answer?

A. Well, it just did not present a problem.

Q. You felt just as happy with it as you would have with a dry concrete runway?

A. I did not say that, but it did not strike me as a problem for taking off.

Q. Did it occur to you there might be differences in the depth of the snow or water on it?

A. No, it did not.

After Capt. Thain had said that a captain accepted responsibility for the safety of his aircraft, the evidence continued:

Q. Including considering the problem of whether the runway surface is not safe enough to take off on?

A. I think that, including that, yes.

Q. You accept that as something which, in appropriate circumstances, he should address his mind to?

A. Yes.

Q. Have you yourself ever gone out on foot or in a vehicle to inspect a runway surface before taking off over it?

A. I cannot recollect having done that, no.

Q. Have you heard of it being done by other captains?

A. In isolated circumstances, yes.

Q. Does it come to you as a surprising statement that other captains may do that in some circumstances?

A. I think you would have to be awfully concerned about the state of the runway.

Q. Before you go and look at it yourself?

A. Yes, for this reason, that there must be a group of airport staff whose job it is to service and look after the airfield, and they cannot just sit back and do nothing about it; one expects it to be up to a certain standard."

Throttling Back

Capt. Thain said that he did discuss with Capt. Rayment before the last run one aspect of taking off on slush, namely whether if throttling back to deal with boost surging produced a swing, it could be corrected by steering the nosewheel without slipping. No other aspect or runway conditions was discussed, and he was quite satisfied. He did not think the slush would retard the aircraft "to any large extent," nor did Capt. Rayment mention such retardation. He had not noticed the retardation on landing, as Capt. Wright had; he thought that although he was not at the controls he would have noticed it if it had happened.

There was no evidence that the captain of any other aircraft departing from Munich that afternoon had experienced any difficulty with the runway or had thought it right to make a personal inspection of its surface or to take any other special steps. Capt. Wright said that the conditions, though not unprecendented, were not often encountered and with his lightly-loaded Viscount he did not consider it necessary

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to inspect the runway, as he had done on some occasions.

There is little that we need add to the recital of the facts set out in above, as a preliminary to considering the third question put to us. The Peravia record shows that at the first attempt power was applied to the port engine for about 32 sec. and that it took about 14 sec. to reach full power. On the second attempt it took about 25 sec. to reach full power, corroborating Capt. Thain's statement that the throttles were opened more slowly; power was applied for about 32 sec. On both these occasions the boost is recorded as reaching somewhere between 59 and 60 in. Mr. Black was so familiar with boost surging at Munich that on seeing the aircraft returning to the tarmac, he felt sure it had been encountered.

Having set out the relevant facts, and our views on Capt. Thain's representations upon disputed questions of fact, we are now in a position to deal with the three questions upon which we are required to give our opinion. The first is whether Capt. Thain took sufficient steps to satisfy himself that the wings of the aircraft were free from ice and snow. In forming our views on this question, we have to bear in mind that our task is to consider the steps which Capt. Thain took up to the third and last attempted takeoff. Had the relevant time been that of the first takeoff the considerations would have been different.

Taxi Clearance

The aircraft first asked for taxi clearance at 1519 hr., and at that time Capt. Thain had had recent experience of conditions outside the cockpit. He had not ascertained the recorded temperature, nor himself inspected the upper surface of the wings, but he had had the report, made some 40 min. earlier, from Capt. Rayment, and he himself had seen the water running from the trailing edge. It may be that at that stage his decision not to have the wings swept or de-iced was correct; the decision accorded with Mr. Black's views, and Mr. Black had had the best opportunity to judge, having been upon the wings throughout refueling. But the time we have to consider is not 1519 hr. but 1556 hr., when the Elizabethan reported ready to taxi for the last time. It was then at least 40 min. and probably longer since Capt. Thain had watched the thawed snow falling from the wing, and 78 min. since refueling had ceased and anyone had inspected the whole upper surface of the wings. It was also 56 min. since the screen temperature had reached zero and within 4 min. of the time when the reading was taken as −0.2C. Since the previous decision the aircraft had taxied to one end of the runway, made two runs, and taxied back from the other end, and, experiencing whatever temperature variations there might be in its path and having any evaporative cooling accelerated by the forced draught generated by its speed.

In these circumstances we have no doubt that Capt. Thain ought to have made a personal inspection of the wings before reaffirming the decision neither to sweep nor to de-ice. Inspection means obtaining a ladder or stand and examining the top of the wings, not looking at the small portion

visible from the cockpit. It is clear from the answers reproduced above that Capt. Thain's omission to take this or any other positive step originated in his ignorance of the ambient temperature, and his failure to acquaint himself with the available information on this subject was, in our view, a serious error. We find that he departed with some snow on his wings, in breach of the BEA instructions; the factors making it impossible for us to say, positively, on the evidence before us whether there was ice under the snow, are factors emphasising the necessity for practical examination at the time. Capt. Thain had then far less information that we have, and the greater the doubt the greater the necessity for precautions. The facts that he was unfamiliar with Munich, and had no great experience of weather of the kind in question should also have led him to act with caution. We think it true to say that he had a great deal on his mind, in that he had been unexpectedly confronted with the boost surging; this is a matter which may help to explain his actions, but it cannot affect our finding that to the first question we must return a negative answer.

In approaching the second question, namely whether Capt. Thain took sufficient steps to ascertain whether or not in the conditions prevailing at the time the runway was fit for use, we recognize that for a captain to make a personal inspection of a runway is an extreme and infrequent action. Capt. Thain found the runway being used without comment by arriving and departing aircraft, and regarded as safe by the airport authorities; these matters, as he accepts, did not absolve him from responsibility, but he was entitled to have regard to them. The duty upon him was perhaps higher than in the case of captains of some other aircraft using the runway that afternoon because of his long takeoff run, lengthened by the necessity to correct the boost fluctuation; but, as he said in evidence, Munich was not a marginal airport, and he would have had no reason to suspect that he had not enough runway unless he had possessed a knowledge of the drag effects of slush which was not then available. Furthermore, had he made an inspection and found the conditions to be as described by Bartz he would have rightly accepted the runway as safe, whereas had he noted from the ground, as he had from his cockpit, a change in the character of the slush at the two-thirds point along the runway, he could not be expected, in the then prevailing state of knowledge of slush-effects, to have appreciated its significance. We find therefore that he did take sufficient steps to ascertain whether in the prevailing conditions the runway was fit for use.

The third question is whether Capt. Thain took sufficient steps to ascertain the cause of the difficulties encountered on the first two attempts to take off before making a third attempt. This question presents no difficulty. We have no doubt that Capt. Thain acted correctly in consulting with the station engineer and that the trouble was correctly diagnosed. We think he acted properly in deciding to make the third attempt.

In conclusion, we think it right to emphasize that while we are unable, for the

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reasons given, to reach a firm finding upon Capt. Thain's representations that there was no ice on the wings during the final run and that the accident was due solely to slush drag, this uncertainty does not affect our answers to the questions posed in our terms of reference. Had Capt. Thain established that there was no wing icing, our answer to the first question would still have been "no," and had he established slush drag as the sole cause of the aircraft's behaviour, our answer to the second question would still have been "yes."

We therefore have to report that we have given full consideration to the representations made to us by and on behalf of Capt. Thain with regard to the accident to the Elizabethan aircraft G-ALZU at Munich on Feb. 6, 1958, that we have had regard to the report of the German Commission of Inquiry into the said accident, including that Commission's reasons for refusing to reopen their inquiry, and that in our opinion Capt. Thain did not take sufficient steps to satisfy himself that the wings of the aircraft were free from ice and snow, but that in our opinion he did take sufficient steps to ascertain whether or not in the conditions prevailing at the time the runway was fit for use and did take sufficient steps to ascertain the cause of the difficulties encountered on the first two attempts to take off before making a third attempt.

E. S. Fay
R. P. Wigley
A. R. Collar

Following is a statement referring to the preceding report by the British reviewing body, submitted by British Airline Pilots Assn., outlining its position in regard to the Elizabethan accident and its pilot:

The British Air Line Pilots Assn. has received the report of the Fay Commission and wishes to congratulate the members of the reviewing body on the scope of the inquiry and the clarity of the report.

While the association accepts the findings of the Commission on the three questions posed in the terms of reference, the association is seriously disturbed by the state of affairs to which the Commission's report draws attention.

Since the report of the German inquiry into the accident at Munich, the association has had to deal with two different problems in respect of the accident and in commenting upon the report of the Fay Commission it would like to deal with each of those problems in isolation.

• **The technical problem.** The Fay Commission makes it plain that the criticisms of the German report made by the association have been justified. The German inquiry employed an assumption that drag caused by slush decreased with the speed of the airplane. The Fay Commission reports that it is now known as a result of research initiated, partly at least, as a result of the Munich accident that the drag caused by slush increases with speed—probably as the square of the speed. The association submits that conclusions should never have been attempted until research had been undertaken. It is for these reasons that the association has pressed throughout for a reopening of the inquiry or a review of the available evidence by a body fully qualified to determine the true cause of the accident. The fact that the Fay Commission was unable to say with any degree of certainty that the accident occurred either as a result of wing icing or as a result of the retarding effect of slush even when it was able to consider a large amount of evidence not available to the German authorities indicates

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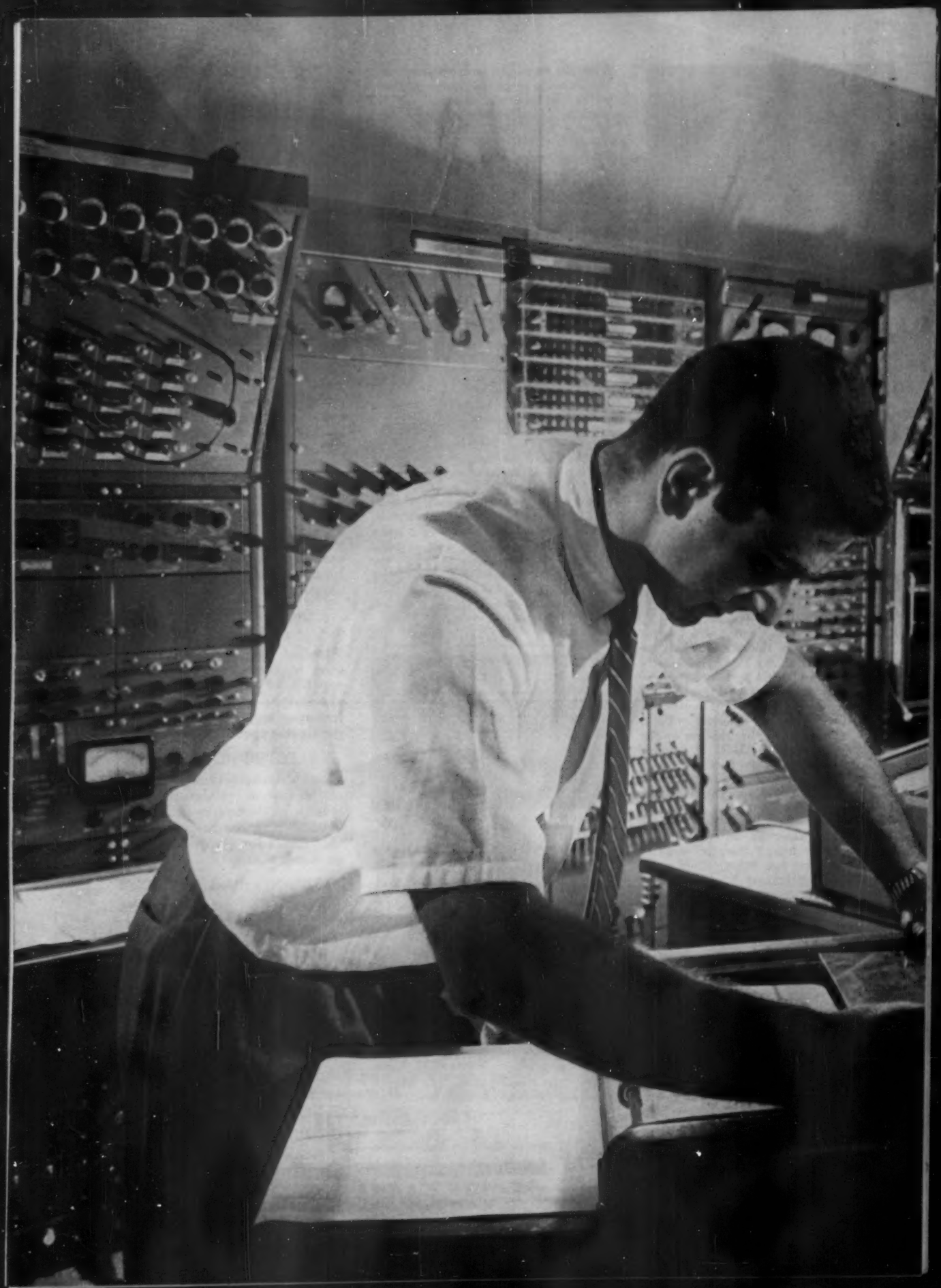

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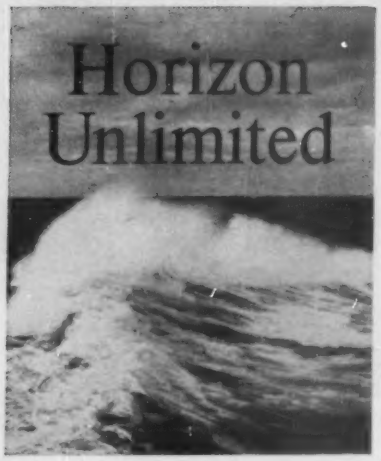

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that the cause of the accident is still not established.

• **License aspect.** On the licensing aspect the association submits that the Minister's powers to withhold renewal of a pilot's license should be exercised to maintain the level of safety. When the renewal of a pilot's license is impeded subsequent to an accident it is important that the cause of the accident be established accurately.

Even an inadequate inquiry may lead to improved safety measures, as the German inquiry has led to the introduction of instructions to pilots concerning takeoff in conditions of slush. But the responsibility of a pilot for an accident must be established with a much greater degree of probability before his license to practise his profession is withdrawn.

At the time of this particular accident Article 17 (vi) of the Air Navigation Order (1954) stated that the pilot in command should satisfy himself that the wings and control surfaces were free from ice and hoar frost. This regulation specifically did not mention deposits of snow. While it is clear, and indeed admitted, that neither of the pilots made a physical inspection of the wings and control surfaces of the aircraft immediately before the final attempt to take off, this does not mean that both pilots were not themselves satisfied as to the condition of the aircraft. The Fay Commission finds that Capt. Thain failed to comply with the regulations. It is because it is stated in the conclusions of the Fay Commission's report that even if it could be proved beyond doubt that no ice had been present on the aircraft, the Commission would still have found that Capt. Thain had failed to comply with the regulations, that the association accepts the finding of the Commission on this aspect.

The Minister reported to the House of Commons that his decision on Capt. Thain's license would depend upon the review made by the Fay Commission. Since the Fay Commission casts doubts as to the validity of the conclusions of the German inquiry which conclusions influenced the Minister's attitude toward the renewal of the license in the first place, it may be expected that renewal will not now be impeded. However, the Fay Commission report is two-years and eight months subsequent to the accident and the conclusions of the German inquiry upon which doubt is now cast have resulted in a grave—albeit temporary—injustice to Capt. Thain.

In conclusion, there has been criticism that the association has failed to maintain an objective position in this matter. It is apparent from the report of the Commission that this criticism cannot be upheld and that all the facts, even those which argued against the case put forward by the association, were laid before the Commission, an action to which the Commission pays specific tribute.

D. Follows
General Secretary,
BALPA

(Capt. Thain, who was discharged by BEA on grounds that he violated regulations by occupying the right seat when he was in command, still holds his license. However, his instrument, type and medical ratings have lapsed.—Ed.)

WHO'S WHERE

(Continued from page 23)

Changes

H. P. Roberts, general manager of the newly formed Space Systems Technology Group, The Siegler Corp., Los Angeles, Calif.

Robert D. Roche, aerospace development sales manager, Lockheed Aircraft's Georgia Division, Marietta, Ga.

R. S. Erickson, director-Polaris computer program, Control Data Corp., Minneapolis, Minn., and **E. D. Zimmer**, manager-Polaris engineering department. Appointed Polaris engineering department supervisors: **C. E. Pallas**, Digital Design Section; **T. A. Hauge**, Analog Design Section; **A. O. Hoistad**, Mechanical Design Section; **P. J. Codute**, Specifications and Standards Section.

The Martin Co., Baltimore, Md., has named **Carlos de Moraes** as program manager for Martin's Apollo study contract with the National Aeronautics and Space Administration.

Richard L. Shelton, director of operations, Telecomputing Corp.'s Whittaker Gyro Division, Van Nuys, Calif.

Sanders Associates, Nashua, N. H., has appointed the following managers in the company's newly established Advanced Systems Laboratories, Burlington, Mass.: **Ethridge C. Best**—advanced weapon systems planning; **Russell B. Hawes**—operations; **Kenneth Dollinger**—advanced development.

Darrell D. DonCarlos, manager of bypass engines and rocket sales, Allison Division of General Motors Corp., Indianapolis, Ind., succeeding **Richard L. Coffey**, now manager of Allison's Los Angeles (Calif.) zone office.

John L. Heins, director-defense systems, Servo Corporation of America, Hicksville, N. Y.

Robert E. Bell, district sales manager-Army programs, General Electric Co.'s Heavy Military Electronics Department, with offices in Washington, D. C., succeeding **H. N. McIntyre**, who has been assigned to GE's subsidiary in The Hague, Netherlands.

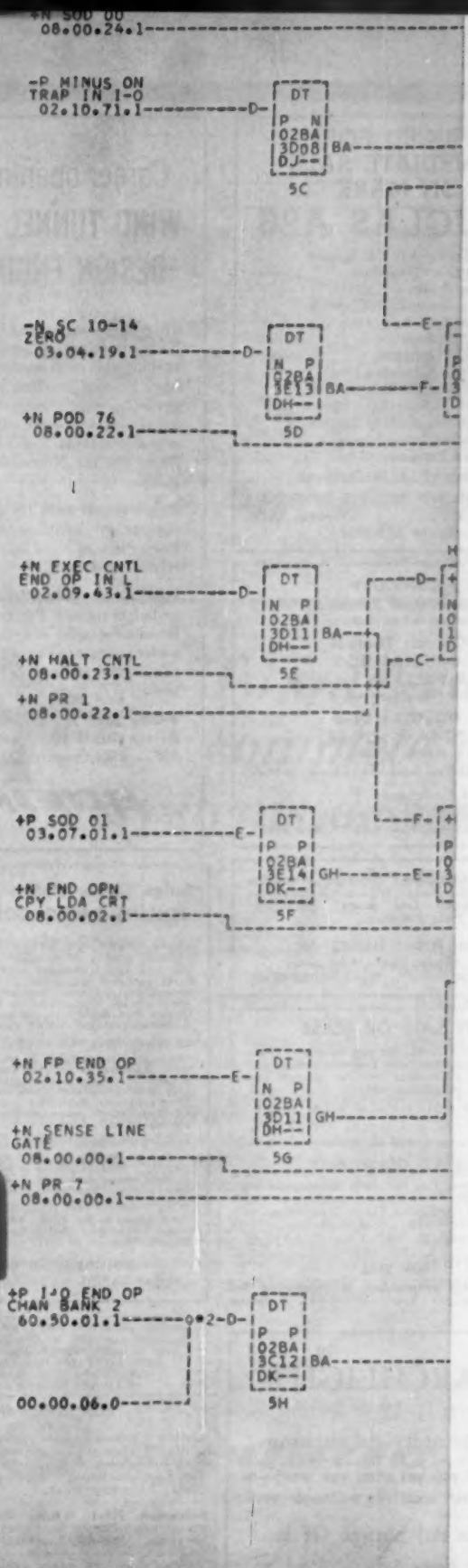
R. M. MacIver, manager, Colorado Springs (Colo.) office of the Convair Division of General Dynamics Corp., succeeding **R. W. Warden, Jr.**, now assistant to the director of military relations, Convair, San Diego, Calif.

Avco Corp.'s Research and Advanced Development Division, Wilmington, Mass., has formed a new undersea projects office at New London, Conn., and has named **Briscoe Chipman** as director.

Dr. George K. Chacko, manager-operations research, Semiconductor Division, Hughes Aircraft Co., Newport Beach, Calif., and **Rainer Zuleeg**, senior staff physicist.

Space Systems Operations of Ford Motor Co.'s Aeronutronics Division, Newport Beach, Calif., has appointed the following as managers of the Space Surveillance Program: **Leigh A. Brite**—space surveillance activity; **Dr. William T. Clary**—systems engineering; **Dr. Gerhard R. Miczaika**—surveillance technology.

Frank G. Willey, manager-infrared systems, Missile Electronics and Controls Division, Radio Corporation of America, Burlington, Mass.



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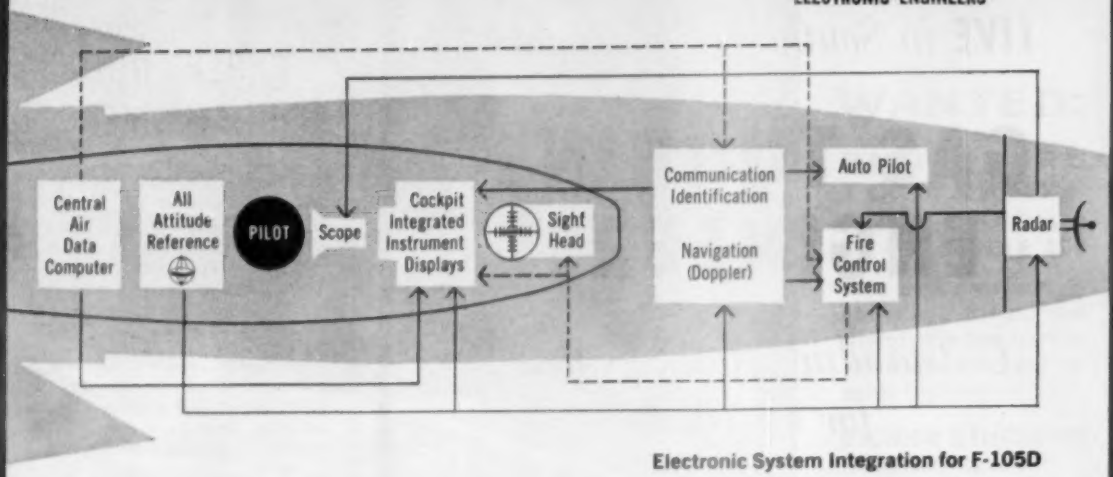

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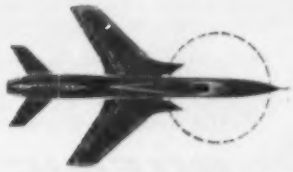

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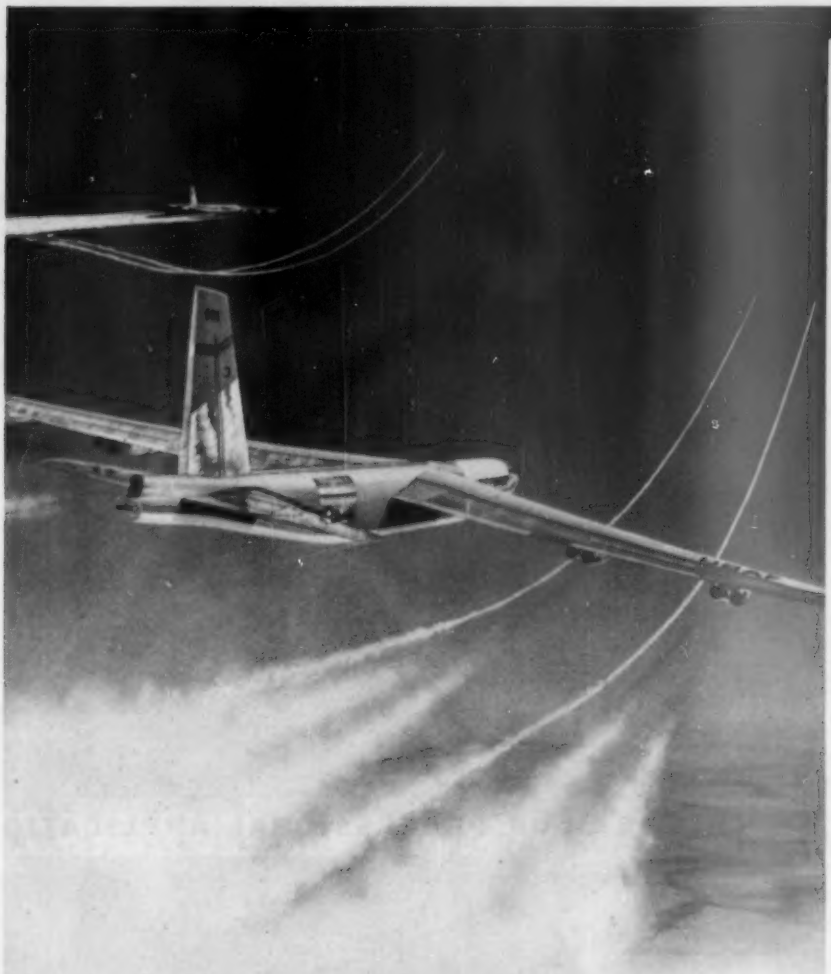

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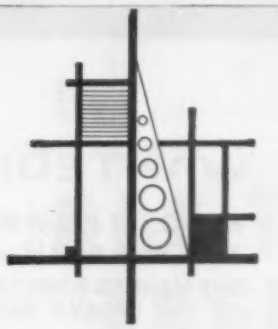

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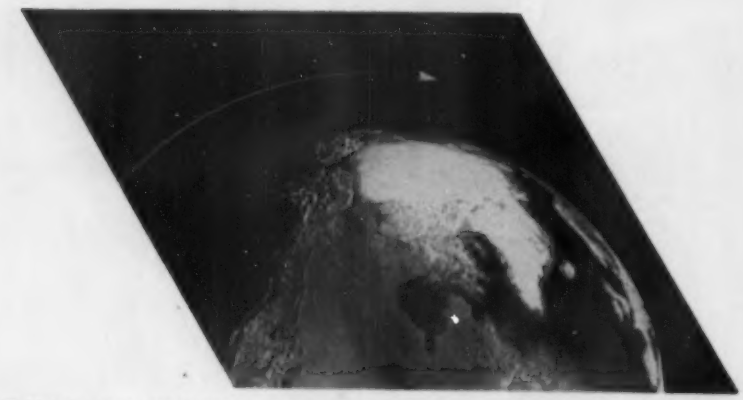

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LETTERS

Dutch Bilateral

It was with much interest that we read the article by Mr. L. L. Doty in AVIATION WEEK of Oct. 17 (p. 38), concerning the bilateral air agreement between the U.S. and The Netherlands.

It is stated in this article that KLM officials in Holland have openly hinted to AVIATION WEEK that Dutch withdrawal from NATO may be one of the major repercussions resulting from failure to grant KLM its desired route.

I would like you to know that this statement is not correct. It has been confirmed to me by my management in Holland that no responsible KLM official either in The Hague or anywhere else could have expressed, or even implied, anything so far from the truth.

From the beginning it has been and continues to be the policy of The Netherlands to support NATO staunchly. As a matter of fact, the record will show you that The Netherlands have been one of the champions of this organization. This has very recently again been confirmed by Her Majesty the Queen of The Netherlands in her address from the throne to the Parliament at the occasion of opening this year's session.

In order to eliminate any misunderstandings which might be created by Mr. Doty's statement, it would be appreciated if you could rectify this error in his article.

D. J. KOELEMAN
Vice President and General Manager, U.S.A.
K. L. M. Royal Dutch Airlines
New York, N. Y.

(Mr. Doty's statement is accurate.—Ed.)

Although it has been well over a month since the article on KLM's drive for West Coast traffic rights appeared in AVIATION WEEK, the longer I consider the Dutch attitude in the case the more irritated I become.

It seems to me, first of all, that the U.S. is in quite a favorable position to bargain as much as it pleases. The only American carrier operating to The Netherlands is Pan-Am, through Amsterdam alone. This route —not among PanAm's lucrative transatlantic routes to other cities—is plainly of much less importance to it than these other routes (as the system timetable can show), whether through competition from KLM or simply the desire to attract public interest to the other routes that earn more revenues for the relative amount of money invested.

KLM Royal Dutch Airlines, on the other hand, derives the majority of its income, I am sure, from its New York-Amsterdam route, as well as the accrual of both passengers continuing onward from Amsterdam to other points east and the general prestige for itself and The Netherlands. In view of these facts, were the U.S. government to cancel KLM's operating rights to New York (and Houston, for that matter) and also advise PanAm to terminate its services to Amsterdam, the effect on KLM would be cataclysmic, but PanAm would scarcely notice the change to its traffic. The likelihood of this situation ever materializing is, of course, nil, but it does demonstrate what I would consider to be the rather foolish and definitely unfounded KLM assertion that the U.S. has little right to bargain on an economic basis or, I might add, on any basis they might choose to discuss.

Casting the assertion aside, the issue of balance of traffic rights between airlines of the two countries can be considered. However, here also KLM appears to have little ground for argument. As your article states, The Netherlands claims it is restricted in its operation to the U.S., being limited to four particular routes, while the U.S. has supposedly unlimited rights, from any U.S. point to any Dutch territory point.

Agreed, a written statement of these provisions appears to give the U.S. an advantage over The Netherlands, but the number of cities or air miles involved is no basis for equating the value of the provisions. It so happens that the four routes operated by KLM are comfortably rich in traffic as far as KLM is concerned, while the routes open to the U.S. carriers—involving the obscure territories of Surinam and the Antilles—are such white elephants, as if the Dutch authorities didn't know it, that no U.S. carrier avails itself to them. Furthermore, the right to operate from any and all U.S. points is too ridiculous even to consider. Hence the U.S. has unrestricted rights to routes worth nothing (except the limited-value Amsterdam route) while The Netherlands is "restricted" to four routes which are, to them, invaluable.

Last, the U.S. advised the Dutch officials that West Coast rights weren't available to just any airline that asked for them, but to those that could arrange an equitable exchange of economic benefits between the U.S. and foreign country involved. The Dutch replied, in truth, that no further economic benefits could be arranged on their part because there were no more to be had.

Well, why should the U.S., in effect, be forced to give something for nothing, even in the face of "affairs of state" harassment? And there is surely nothing odd about the reluctance of U.S. airlines to leap into the West Coast-Amsterdam market when the returns from the New York-Amsterdam market—in comparison with other transatlantic routes—are only mediocre. If KLM and The Netherlands have any remaining grounds for argument of West Coast traffic rights, it seems to me that they had better remove what should be called insolence from their plan of attack for obtaining those rights.

BRUCE HAXTHAUSEN
Adelphi College
Huntington, N. Y.

Aviation Week welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42nd St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

SECOR Transponders

I noticed with interest your article entitled "Transit IIIA Planned for Nov. 29 Launch" (AW Nov. 7, p. 57).

As pointed out to me by a number of persons interested in Cubic's activities, this article states that the Navy is considering elimination of the SECOR transponders planned for installation in this satellite. This article has caused some misunderstanding as it leaves the opinion that the geodetic SECOR system was originally considered a part of the Transit program. In order to clear the air with those persons interested, the geodetic SECOR transponder was to be carried in Transit on a non-interference basis and is not a part of the Navy's Transit program. The geodetic SECOR program is being sponsored by the Army Map Service and the transponder was planned for installation in Transit simply as a courtesy and convenience for early checkout of our geodetic SECOR mapping equipment. Due to recent developments with the Navy's Transit equipment, the geodetic SECOR transponder will probably not be placed in Transit IIIA but geodetic SECOR transponders will be carried by later Transit satellites. In addition, geodetic SECOR transponders will be carried in some interim geodetic satellites planned by the Army and in a number of satellites to be used in a Joint Services Geodetic Satellite program currently in the planning stage.

ROBERT V. WERNER
Executive Vice President
Cubic Corp.
San Diego, Calif.

Airline Clubs

I was amazed to read in the Nov. 21 issue of your magazine under the topic Airline Observer (p. 50), that the CAB is making an investigation of the Admirals Club and the Ambassador Club, operated by two of the domestic airlines.

It would appear that the CAB would have far greater problems than following the complaints of a few disgruntled persons on such matters. I have been a member of one of the clubs named for 15 years and the other for three years. Never has it even been suggested that I was to get any preference because of any membership in such clubs. They are in only a few of the major cities and cannot be construed as a "special deal" for anyone. I do not think C. R. Smith, president of American, would ever permit such a situation to exist.

What I think has happened is that someone has sounded off, as did one passenger in the lounge on a trip I made to Seattle just recently. He said his boss was a member of one of these clubs and could even get people removed from a flight. I challenged the statement and the man then admitted he had absolutely no proof and thought that was what he had heard his boss state. Let's get more attention to more pressing matters—of which there are many.

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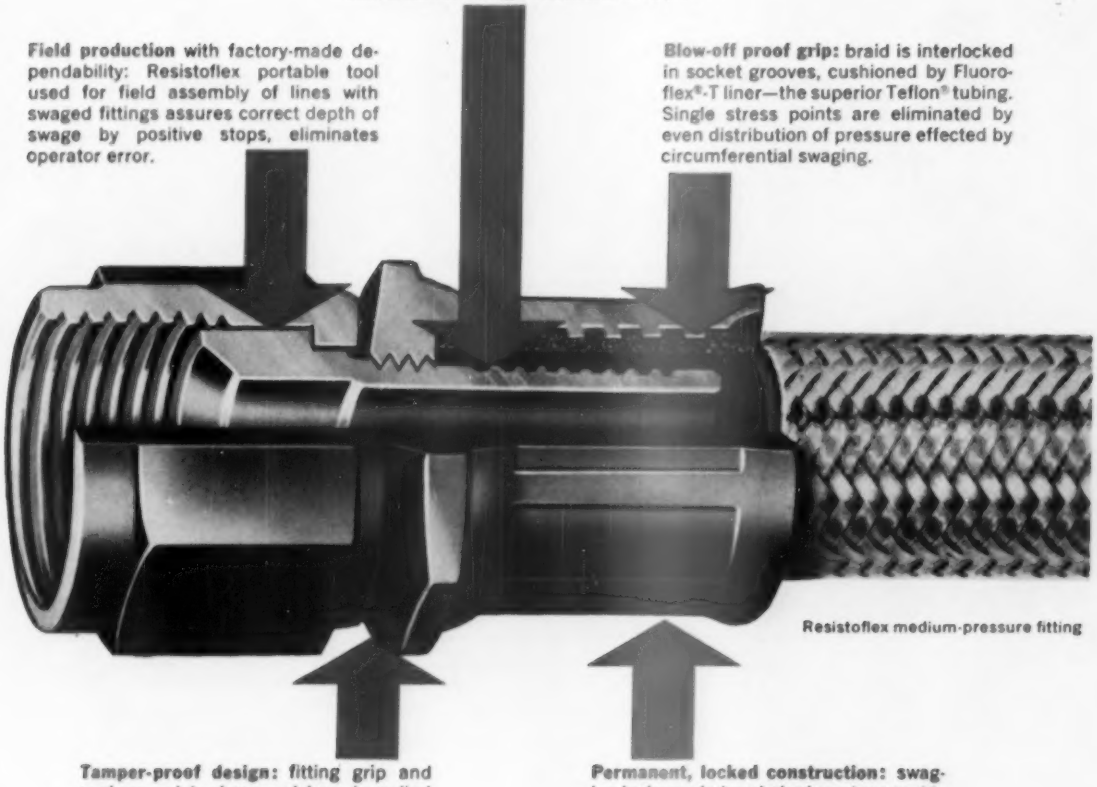

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